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PROCEEDINGS

OF THE

AMERICAN SOCIETY

OF

CIVIL ENGINEERS.

(INSTITUTED 1852.)

VOL. XXXI.

JANUARY TO DECEMBER, 1905.

NEW YORK:
PUBLISHED BY THE SOCIETY.
1905.

Entered according to Act of Congress, by the AMERICAN SOCIETY OF CIVIL ENGINEERS,
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PROCEEDINGS

OF THE

AMERICAN SOCIETY

OF

CIVIL ENGINEERS.

(INSTITUTED 1852.)

VOL. XXXI. No. 1.
JANUARY, 1905.

Edited by the Secretary, under the direction of the Committee on Publications.

Reprints from this publication, which is copyrighted, may be made on condition that the full title of Paper, name of Author, page reference, and date of presentation to the Society, are given.

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NEW YORK 1905.

Entered according to Act of Congress, by the American Society of Civil Engineers in the office of the Librarian of Congress, at Washington.

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Vol. XXXI. JANUARY, 1905. No. 1.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PROCEEDINGS.

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SOCIETY AFFAIRS.

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MINUTES OF MEETINGS.

OF THE SOCIETY.

January 4th, 1905.—The meeting was called to order at 8.40 P. M., G. W. Tillson, M. Am. Soc. C. E., in the chair; Chas. Warren Hunt, Secretary; and present, also, 88 members and 12 guests.

The minutes of the meetings of December 7th and 21st, 1904, were approved as printed in the *Proceedings* for December, 1904.

A paper entitled "Methods of Location on the Choctaw, Oklahoma and Gulf Railroad," by F. Lavis, Assoc. M. Am. Soc. C. E., was presented by the author. The paper was discussed by Messrs. E. Sherman Gould, G. H. Thomson, and the author.

Ballots for membership were canvassed, and the following candidates elected:

AS MEMBERS.

JOHN WILLIAM BARNETT, Athens, Ga.
ERNEST WILDER CLARKE, Cristobal, Canal Zone, Panama.
CLOUD CLIFFORD CONKLING, Buffalo, N. Y.
WILLIAM EASBY, JR., Philadelphia, Pa.
JACOB MARTIN FLOESCH, Rochester, N. Y.
PORTER DWIGHT FORD, Richmond Hill, N. Y.
JAMES COTTLE HALLSTED, New York City.
JOHN ALBERT KNIGHTON, New York City.
JACOB STINMAN LANGTHORN, New York City.
DAVID SPENCER MERRITT, Tarrytown, N. Y.
EMIL NEWMAN, Los Angeles, Cal.
FRANKLIN AUGUSTUS SNOW, Boston, Mass.

AS ASSOCIATE MEMBERS.

HOWARD EDWARD BOARDMAN, New York City.
FRANK HARVIE CARTER, Waterville, Me.
HARRY OUTEN COLE, New York City.
HERMAN CONROW, New York City.
JAMES HAVEN CROSETT, San Francisco, Cal.
JOHN WILLIAMS DOTY, New York City.
WILLARD FRANKLIN GRAVES, Chicago, Ill.
GRANBERY JACKSON, Nashville, Tenn.
WARREN BYRON KEIM, Harrisburg, Pa.
JAMES LEONARD LYTEL, Montrose, Colo.
ROBERT HENRY MCPHERSON, New York City.
CHESTER JOHN MYERS, Atlantic City, N. J.
LUTHER STEVENS OAKES, Seattle, Wash.
MOSES EDMUND SHIRE, Chicago, Ill.
JOHN JERVIS VAIL, Rahway, N. J.

The Secretary announced:

The transfer of the following candidates, by the Board of Direction, on January 3d, 1905:

FROM ASSOCIATE MEMBER TO MEMBER.

HENRY CLAYTON ALLEN, Albany, N. Y.
CLINTON SUMNER BURNS, Kansas City, Mo.
WILLIAM CONQUEST TUCKER, New York City.
DANIEL LAWRENCE TURNER, New York City.
WILBUR JAY WATSON, Cleveland, Ohio.

The election of the following candidates, by the Board of Direction, on January 3d, 1905:

As JUNIORS.

ROGER DERBY BLACK, Fort Leavenworth, Kans.
HERBERT WILLARD GODDARD, New York City.
PAUL HANSEN, Columbus, Ohio.
THAYER LINDSLEY, New York City.
CURLYS LYON SLOCUM, New Haven, Conn.
ACHILLE OCTAVE VAN SUETENDAEL, Yonkers, N. Y.
DONALD CRAMER WAITE, Yonkers, N. Y.

The Secretary announced the death of JOHN MILLER CUNNINGHAM, elected Associate Member October 7th, 1903; died August 8th, 1904.

Adjourned.

January 18th, 1905.—The minutes of this, the Annual Meeting, will be printed in the *Proceedings* for February, 1905.

OF THE BOARD OF DIRECTION.

(Abstract.)

January 3d, 1905.—Vice-President Deyo in the chair; Chas. Warren Hunt, Secretary; and present, also, Messrs. Buck, Craven, Croes, Ellis, Gowen, N. P. Lewis, Pegram, Osgood and Webster.

Action was taken in regard to members in arrears for dues.

The Annual Report of the Board was adopted for presentation to the Annual Meeting.

The following report was received from the Committee on Award of Prizes:

"Nov. 30, 1904.

"MR. CHAS. WARREN HUNT,
"*Secretary*, Am. Soc. C. E.,
"220 W. 57th St., New York.

"DEAR SIR:

"The undersigned Committee, appointed for this purpose, have the honor to recommend the award of prizes for the year ending with the *Transactions* for the month of July, 1904, as follows:

"The Norman Medal to Mr. Emile Low for his paper No. 971, on The Breakwater at Buffalo, N. Y.

"The Thomas Fitch Rowland Prize to Mr. George Cecil Kenyon for his paper No. 970, on Dock Improvements at Liverpool.

"The Collingwood Prize for Juniors to Mr. Herbert J. Wild for his paper No. 976, on The Substructure of Marsh River Bridge.

"Respectfully submitted,
"CHARLES L. STROBEL,
"SAMUEL TOBIAS WAGNER,
"J. L. LUDLOW,
"*Members Committee.*"

The Norman Medal, The Thomas Fitch Rowland Prize, and the Collingwood Prize for Juniors were awarded in accordance with the recommendation of the above report.

Announcement was made of the election, on December 16th, 1904, of Sir William Henry White, as Honorary Member of the Society.

A Local Committee of Arrangements for the next Annual Convention was appointed.

Correspondence between Sir William H. White, President, Inst. C. E., and Charles Hermany, President, Am. Soc. C. E., was presented and ordered printed in *Proceedings* for the information of members.

The following resignations were accepted as taking effect December 31st, 1904:

MEMBERS:
- LATHAM ANDERSON,
- NORTON L. TAYLOR.

ASSOCIATE MEMBER:
- HARRY LINCOLN NOYES.

JUNIORS:
- FREDERICK F. HALL,
- GEORGE C. HOPKINS, JR.

Applications were considered and other routine business transacted.

Five Associate Members were transferred to the grade of Member, and seven candidates for Junior were elected.

Adjourned.

VISIT OF MEMBERS OF THE INSTITUTION OF CIVIL ENGINEERS.

The following letters are printed for the information of the membership:

"THE INSTITUTION OF CIVIL ENGINEERS,
"Great George Street, Westminster, S. W.
"8 NOVEMBER, 1904.

"CHARLES HERMANY, Esq.,
*"President of the
"American Society of Civil Engineers.*

"MY DEAR SIR: The Council of the Institution of Civil Engineers desire me to express to you, as President of the American Society of Civil Engineers, their high appreciation of the courtesy and kindness shown by your Society to members of the Institution during the recent visit to the United States.

"Their special thanks are due to the Reception Committee and to the Secretary of your Society for the admirable arrangements made throughout their visit, by which opportunities were provided for visiting many of the most recent and important Engineering works, while their comfort in travelling was secured. The Council will be grateful if you will convey to the various authorities the sincerest thanks of those members who formed the party, and of the Institution as a whole, for the facilities so generously afforded.

"The ladies of our party desire to acknowledge their indebtedness to the American ladies for the unfailing kindness and consideration shown to them, and for the many pleasant excursions arranged in New York and Chicago.

"Your splendid hospitality well maintained the national repute, and will not be forgotten.

"The Council learn with satisfaction that the International Engineering Congress at St. Louis, organized by your Society, was a complete success, and trust that this result was due, in some degree, to the large representation of the Institution by members attending not merely from the mother country but from all parts of the British Empire.

"The acceptance of the cordial invitation of the American Society of Civil Engineers was intended by the Council to mark their high esteem of their professional brethren upon whom rests the responsibility for the great Engineering works of the United States. This action was unprecedented in the history of the Institution, and its happy results are welcomed by the Council, who feel confident that the visit will tend to draw closer the connection between American and British Civil Engineers, and to strengthen the friendship and cordial relations of the two countries.

"I am,
"My dear Sir,
"Yours faithfully,
"W. H. WHITE."

"LOUISVILLE, KY., No. 549 Third St.,
"DEC. 31, 1904.

"SIR WILLIAM H. WHITE,
"President, Institution of Civil Engineers,
"LONDON, ENGLAND.

"DEAR SIR: Your courteous and friendly letter of the 8th ult., to the American Society of Civil Engineers, was duly received, and for the graceful compliments and friendly sentiments therein expressed, the American Society makes respectful acknowledgment and will take pleasure in making known to its Members this formal announcement by the Institution of Civil Engineers of the high esteem and appreciation with which it regards our endeavors to honor and serve them, our recent distinguished guests.

"The remembrance of the series of pleasant events, with the numerous surprising and charming proofs of race affinities and high professional and national esteem, will be cherished memories by those who participated in professional and social functions, and the report thereof read by all the Members with pride and joy. It gives us pleasure to convey to your Council the fact that in this sentiment the American ladies join us, and to add that it reflects a universal sentiment among us.

"An account of your visit (though brief) and those of the English ladies who accompanied you, with the friendly intercourse resulting therefrom, will go on record as an epoch in our Society's history.

"Very Respectfully and Cordially yours,
"CHAS. HERMANY,
"President."

ANNOUNCEMENTS.

The House of the Society is open from 9 A. M. to 10 P. M. every day, except Sundays, Fourth of July, Thanksgiving Day and Christmas Day.

MEETINGS.

Wednesday, February 1st, 1905.—8.30 P. M.—A regular business meeting will be held. Ballots for membership will be canvassed, and a paper entitled "Maximum Rates of Rainfall at Boston," by Charles W. Sherman, M. Am. Soc. C. E., will be presented for discussion.

This paper was printed in *Proceedings* for December, 1904.

Wednesday, February 15th, 1905.—8.30 P. M.—At this meeting a paper entitled "The Water-Works of Porterville, California," by Philip E. Harroun, M. Am. Soc. C. E., will be presented for discussion.

This paper is printed in this number of *Proceedings.*

Wednesday, March 1st, 1905.—8.30 P. M.—A regular business meeting will be held. Ballots for membership will be canvassed, and a paper entitled "Technical Methods of River Improvement, as Developed on the Missouri River, by the General Government, from 1876 to 1903," by S. Waters Fox, M. Am. Soc. C. E., will be presented for discussion.

This paper is printed in this number of *Proceedings.*

ANNUAL CONVENTION.

The Thirty-Seventh Annual Convention will be held in Cleveland, Ohio, June 20th-23d, 1905. The following Committees have been appointed to take charge of the arrangements.

COMMITTEE OF THE BOARD OF DIRECTION:

ALFRED CRAVEN, *Chairman;*
N. P. LEWIS,
W. J. WILGUS,
CHARLES S. GOWEN,
CHAS. WARREN HUNT.

LOCAL COMMITTEE:

A. MORDECAI, *Chairman;*
W. P. BROWN,
WM. J. CARTER,
E. A. HANDY,
A. M. JOHNSTON,
M. W. KINGSLEY,
J. FRANCIS LE BARON,
F. C. OSBORN,
W. P. RICE,
J. RITCHIE,
S. T. WELLMAN,
C. H. WRIGHT.

PRIVILEGES OF LOCAL SOCIETIES EXTENDED TO MEMBERS OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS.

The Boston Society of Civil Engineers will welcome any member of the American Society of Civil Engineers at its library and reading room, 517 Tremont Temple, Boston, which is open on weeks days from 9 A. M. to 5 P. M. Members will also be welcome at the meetings, which are held in the same building, on the evenings of the fourth Wednesday in January, and the third Wednesdays of other months, except July and August.

The rooms of **The St. Louis Engineers' Club** are in the business center of St. Louis, and visiting engineers are cordially invited to use them for mail, telephone service, information, etc.

The courtesies of **The Engineers' Society of Western Pennsylvania** have been extended to members of the American Society of Civil Engineers. The rooms of the Society, 410 Penn Ave., Pittsburg, Pa., are open at all times, and meetings are held as follows, except during July and August. REGULAR SECTION, Third Tuesdays; CHEMICAL SECTION, Thursdays following third Tuesdays; MECHANICAL SECTION, First Tuesdays; STRUCTURAL SECTION, Fourth Tuesdays.

The Western Society of Engineers, Monadnock Block, Chicago, Ill., tenders to members of this Society the use of its rooms and facilities, together with the good offices of its Secretary and of a special committee appointed for that purpose.

The Civil Engineers' Club of Cleveland, Ohio, invites members of this Society to make use of the Club rooms, at any time when in Cleveland. Cards will be furnished on application to the Secretary, Mr. J. C. Beardsley.

The Engineers' Club of Central Pennsylvania has established new quarters at the corner of Second and Walnut Streets, Harrisburg, Pa., and desires to extend the courtesies of the Club to visiting members of the American Society of Civil Engineers.

SEARCHES IN THE LIBRARY.

In January, 1902, the Secretary was authorized to make searches in the Library, upon request, and to charge therefor the actual cost to the Society for the extra work required. Since that time many such searches have been made, and bibliographies and other information on special subjects furnished.

The resulting satisfaction, to the members who have made use of the resources of the Society in this manner, has been expressed frequently, and leaves little doubt that, if it were generally known to the membership that such work would be undertaken, many would avail themselves of it.

The cost is trifling, compared with the value of the time of an engineer who looks up such matters himself, and the work can be performed quite as well, and much more quickly, by persons familiar with the Library.

Copies of all lists of references are filed, so that in many cases it is only necessary to make a typewritten copy, which reduces the cost of searches to a minimum.

In asking that such work be undertaken, members should specify clearly the subject to be covered, and whether references to general books only are desired, or whether a complete bibliography, involving search through periodical literature, is desired.

ANNUAL REPORT OF THE BOARD OF DIRECTION FOR THE YEAR ENDING DECEMBER 31st, 1904.

PRESENTED AT THE ANNUAL MEETING, JANUARY 18TH, 1905.

The Board of Direction, in compliance with the Constitution of the Society, presents its report for the year ending December 31st, 1904.

MEMBERSHIP.

The changes in membership are shown in the following table:

Grade.	Jan. 1st, 1904.			Jan. 1st, 1905.			Losses.				Additions.		Totals.	
	Resident.	Non-Resident.	Total.	Resident.	Non-Resident.	Total.	Transfer.	Resignation.	Dropped.	Death.	Transfer.	Election.	Loss.	Gain.
Honorary Members	1	8	9	1	8	9	..	..	..	1	....	1	1	1
Corresponding Members	....	2	2	....	2	2	..	..	..	..	....	....	....	....
Members	335	1 322	1 657	376	1 419	1 795	..	3	4	25	*61	‡109	32	170
Associate Members	209	600	809	240	663	903	60	2	7	4	†27	140	73	167
Associates	48	77	125	51	76	127	3	1	1	..	....	7	5	7
Juniors	117	176	293	116	224	340	25	5	1	..	....	§78	31	78
Fellows	8	21	29	9	18	27	..	..	..	2	....	....	2	....
Totals	718	2 206	2 924	793	2 410	3 203	88	11	13	32	88	335	144	423

* 60 Associate Members and 1 Junior.
† 3 Associates and 24 Juniors.
‡ 2 Reinstatements.
§ 1 Reinstatement.

From the above table it will be seen that the net increase in membership during the year was 279, the largest yearly increase on record.

As stated in the report of the Board for 1903, the yearly net increase, previous to 1899, reached 100 only in four separate years, no two of which were consecutive. The net increase for each year beginning with 1899 follows:

1899	103
1900	138
1901	190
1902	185
1903	212
1904	279
Total net increase for past six years	1 107
Average net yearly increase for the past six years	184½

For comparison, it may be stated that the average net increase previous to 1899 was as follows:

The average net yearly increase 1870-78 was 48.1
" " " " " 1879-88 " 61.1
" " " " " 1889-98 " 89.3

It is also interesting to note the total number of applications received during the six-year period above referred to.

Total number of applications received during 1899......259
" " " " " " 1900......308
" " " " " " 1901......375
" " " " " " 1902......362
" " " " " " 1903......432
" " " " " " 1904......503

The losses by death reported during the year number 32. They are as follows:

Honorary Member: Charles Storer Storrow.

Members: Danforth Hurlbut Ainsworth, Jacob Neff Barr, Louis Frederic Gustav Bouscaren, James Peter Bogart, Standish Barry Burton, Wilson Crosby, Clark Fisher, Frederick Reginald French, George Clinton Gardner, Joseph Norton Greene, Lorenzo Medici Johnson, Jacob Albert Latcha, Richard Calvin McCalla, Thomas McKeown, Henry Louis Marindin, Alexander Macomb Miller, William Arthur Pratt, B. Frank Richardson, Alfred Rosenzweig, Thomas Pearman Shanks, Reuben Shirreffs, Benjamin Burgh Smith, Selwyn Mellon Taylor, George Curtis Tingley, Alonzo J. Tullock.

Associate Members: Fritz Carl Anders Georg Bergengren, John Miller Cunningham, George Thompson DeForest, Van Norman McGee.

Fellows: James W. Ainslie, William Ward Reed.

LIBRARY.

The accessions to the Library during the year are shown in the following table:

ACCESSIONS DURING THE YEAR 1904.

	Bound Volumes.	Unbound Volumes.	Specifications.	Maps, Photographs and Drawings.	Total.
Donations—					
In answer to special requests	162	604	2	4	772
From publishers	48	4	...	...	52
In regular course....	564	955	137	151	1 807
By purchase	106	39	...	...	145
Totals	880	1 602	139	155	2 776

In addition to the above, there have been received 185 duplicates, and 78 separate numbers to complete files of periodicals, neither of which can appear as accessions. A large number of donations have also been received, which, owing to pressure of other work, have not been catalogued and do not appear in the above figures.

The Library now contains:

Bound volumes	13 462
Unbound volumes	27 353
Specifications	6 002
Maps, photographs and drawings	3 467
Total	50 284

The total number of titles in the Library is 20 310.

During the year, 288 volumes have been bound, and 28 bound volumes which are duplicates were received and have replaced previously unbound volumes.

The following amounts have been expended upon the Library during the year:

Purchase of books, 145 volumes	$490.45
Express charges, etc	46.38
Binding 288 volumes	321.65
Fixtures, supplies and sundries	67.83
Total	$926.31

The value of the accessions to the Library during the year is as follows, each accession having been valued separately, as received:

2 631 Donations and exchanges (estimated value)	$2 038.22
145 Volumes purchased (cost)	490.45
Binding 288 volumes	321.65
Total	$2 850.32

The Board wishes to point out the effect of the policy adopted in 1897, and continued since that time, of thoroughly cataloguing and indexing the Library, and of the purchase of all new engineering books which cannot be secured by donation. While the first cost and expense of maintenance, of the thoroughly classified index (two volumes of which have already been printed and issued to members), has been large, it seems to have been fully justified. As the aim of the Society to furnish every facility for study and research becomes known to our members and to the public, the Reading Room attendance increases. It should be borne in mind that this attendance is not like that of a club, but that each person recorded in the figures given, visits the Library for study, or to look over Current Technical Literature.*

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* It may be of interest to state that 224 Engineering Periodicals are regularly received and kept on file in the Reading Room.

During the first five years of occupancy of the present house the average yearly Reading Room attendance was 1 712, the largest number of visitors in any one year being 1 794. During 1903 this attendance was 2 075, and in 1904 increased to 3 475.

In addition to this, members frequently take advantage of the opportunity given to have searches made, and this work now takes a large part of the time of one of the Assistant Librarians, having increased more than 50% during the past year. Type-written bibliographies of 47 subjects, covering more than 1 000 separate references, have been furnished to members during the past year, and many expressions of gratification as to the character of the work done and the great convenience it is to busy engineers, have been received. The actual cost to the Society is charged for this work, and it may be of interest to state that the average time consumed in finding and type-writing each item is 20 minutes, and the average cost 13 cents.

PUBLICATIONS.

During the year the usual ten numbers of *Proceedings* and two volumes of *Transactions* have appeared.

In the *Proceedings*, the list of references to current engineering literature has covered 102 pages, containing 4 968 classified references to 71 periodicals.

The stock of the various publications of the Society, kept on hand for the convenience of members and others, now amounts to 123 711 copies, the cost of which to the Society, for paper and presswork only, has been $15 391.11.

During the year, 3 083 volumes of the Society publications have been bound, for members and others, in the standard half-morocco or cloth bindings.

The extra publications during the year have been the Advance Copies of the Papers of the International Engineering Congress, referred to in this Report under another head.

SUMMARY OF REGULAR PUBLICATIONS FOR 1904.

	Issued.	Edition.	Total Pages.	Plates.	Cuts.
Transactions (Volumes)*.....	2	3 425	1 098	58	285
Proceedings (Monthly Numbers)*	10	3 535	1 492	55	227
Constitution and List of Members	1	3 900	230	...	1
Total	13	....	2 820	113	513

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* Includes Indexes and Tables of Contents.

The cost of regular publications has been:

For Paper, Printing, Binding, etc., *Transactions* and *Proceedings*		$9 535.92
For Plates and Cuts		1 308.70
For Boxes, Mailing Lists, Copyright and Sundry Expenses		236.95
For Commission on Advertisements		18.52
For 7 450 copies of Memoirs and Papers		574.65
For List of Members		1 029.02
Total		$12 703.76
Deduct amount received from sale of publications	$2 660.97	
Deduct amount received for advertisements	30.00	
		2 690.97
Net cost of Regular Publications for 1904		$10 012.79

MEETINGS.

During the year, 20 meetings have been held, as follows: Annual Meeting, 1; at the Annual Convention, 2; regular semi-monthly meetings, 17.

At these meetings, there were presented 19 formal papers, 4 of which were illustrated with lantern slides, and 3 illustrated lectures.

The Thirty-sixth Annual Convention was held in St. Louis, Mo., in connection with the International Engineering Congress, and the registered attendance numbered 391 members and 485 guests.

MEDALS AND PRIZES.

For the year ending with the month of July, 1903, Prizes were awarded as follows:

The Thomas Fitch Rowland Prize to George W. Fuller, Assoc. M. Am. Soc. C. E., for his paper entitled "The Filtration Works of the East Jersey Water Company, at Little Falls, New Jersey."

The Collingwood Prize for Juniors to Isaac Harby, Jun. Am. Soc. C. E., for his paper entitled "The Footbridge for Building the Cables of the New East River Bridge."

No award of the Normal Medal was made.

SOCIETY HOUSE.

After careful consideration, the Board decided early in the year to acquire, if possible, additional land for the enlargement of the present House, and at its May meeting, at which twenty members of the Board were present, unanimously authorized the purchase of the lot, 25 ft. front, with an average depth of 116 ft., immediately adjoining the present property on the west, and on June 6th, 1904, the title to this property passed to the Society.

The price of this lot was $100 000, and it was necessary that the mortgage debt should be increased to pay for it. The old mortgage debt was $55 000, and it was decided to borrow $120 000 additional, so as to provide, after payment in full of the purchase price, $20 000 additional, available for building purposes.

The Society now owns a plot with 75 ft. frontage on 57th Street, with an average depth of 113 ft., for which it has paid $180 000. A conservative estimate of the present market value of this plot (without buildings) is $255 000.

It was not deemed wise to undertake building operations at once, partly on account of the state of the building trade, and partly because the general disorganization incident to such operations would interfere with the comfortable reception of the many Foreign Engineers who were to visit us during the year. The Board has the matter under advisement, general plans are now being prepared and it is expected that the work of enlargement will go on during the next season.

HEADQUARTERS FOR ENGINEERS, AND SOCIETY EXHIBIT AT ST. LOUIS.

In November, 1902, the Board authorized the establishment of an Engineering Headquarters, and an Engineering Exhibit by the Society, at the Louisiana Purchase Exposition, and appointed a Committee, of which Robert Moore, Past-President, Am. Soc. C. E., was Chairman, to take charge of the matter. In 1903, $3 000 was appropriated for the use of this Committee, and during the past year $4 000 additional has been appropriated, making the total expenditure for this account $7 000. The Committee successfully carried out its plans; a handsome booth was erected near the center of the Liberal Arts Building, in which a creditable exhibit, contributed largely by members of this Society, was installed. O. E. Mogensen, M. Am. Soc. C. E., was placed in charge, for the Committee, and during the entire Exposition a bureau of general information and courtesy for visiting engineers was maintained.

LOCAL COMMITTEES OF INFORMATION AND COURTESY TO FOREIGN ENGINEERS.

At the request of the Board, a number of Members in Baltimore, Boston, Chicago, Cincinnati, Cleveland, Harrisburg, Kansas City, Minneapolis, St. Paul, New Orleans, Niagara Falls, Philadelphia, Pittsburg, St. Louis, San Francisco and Washington, kindly consented to act as Committees, and as individuals, for the purpose of aiding foreign engineers to secure local information while traveling in the United States, to or from the St. Louis Exposition. Each foreigner who called at the Society House was given a general letter of introduction to our Members, to which were appended the names and addresses of the 102 Members above referred to. This plan was very successful, because it made it certain that the visitor to any of the cities named, would be able to find a Member of the Society who would be ready to give him full local information.

The thanks of the Society are due to all the Members who assisted in this manner in the reception of our guests.

VISIT OF MEMBERS OF THE INSTITUTION OF CIVIL ENGINEERS.

The visit of a party of Members of the Institution of Civil Engineers, including the President, Sir William H. White, and the Secretary, Dr. J. H. T. Tudsbery, furnished an occasion of great interest and pleasure to all members of the Society who were able to meet them, either in New York or during their subsequent travels in this country. Their presence at the International Engineering Congress added much to the success of that meeting. A detailed description of the entertainment in New York has been printed in *Proceedings,* and it is only necessary here to add, for the information of members, that the funds of the Society were not drawn upon for this account, the necessary expense having been oversubscribed, and 55% of his subscription having been returned to each subscriber.

INTERNATIONAL ENGINEERING CONGRESS.

In September, 1903, in response to the request of the Authorities of the Louisiana Purchase Exposition, the Board recommended to them a Committee of representative Engineers, to be charged with the organization of an International Engineering Congress, to be held during the Exposition. Such a Committee was appointed, and made every possible effort to secure the co-operation of the American Society of Mechanical Engineers, the American Institute of Mining Engineers, the American Institute of Electrical Engineers, the Society of Naval Architects and Marine Engineers, the Society for the Promotion of Engineering Education and of those Departments of the United States Government in charge of engineering work. The American Society of Mechanical Engineers and the American Institute of Electrical Engineers, however, declined to co-operate in the project, and the Committee reported to the Authorities of the Exposition its inability to organize the proposed Congress. So much time was consumed in the above negotiations that the report of this action of the Committee did not reach the Board until December 1st, 1903.

On January 5th, 1904, the Board decided to undertake, in the name of the Society, the entire organization, financing and management of an International Engineering Congress, and fixed October 3d to 8th as the date at which it should be held. The original Committee, of which Henry S. Haines, M. Am. Soc. C. E., was Chairman, was appointed to take entire charge, in behalf of the Society.

It will be seen that a period of less than nine months was available to carry out the plan of the Committee, made several months before, and, in view of the fact that that plan called for the advance publication and international circulation of papers on selected subjects, to be written by specialists both at home and abroad, none of whom had then been selected, the task seemed almost hopeless. Those who were fortunate enough to attend the Congress, or who have read the lists of Subjects and Authors issued from time to time, and the reports of the two general meetings containing the reports of the Chairmen of the various Sections, and of the Secretary of the Congress,* will understand the feeling with which the Board congratulates the Society and the Profession of Civil Engineering, on the result. The great success of the Congress could not have been achieved but for the prompt and courteous response of the 45 foreign engineers to whom invitations to prepare papers were sent in the name of this Society, and the thanks of the Profession are due to them, as well as to the 52 Americans who accepted similar invitations.

Prior to the date of the Congress 82 papers (a large number of which had to be translated) had been received, prepared for the press, and in advance form, through the agency of Engineering Societies both at home and abroad, placed in the hands of those best qualified to discuss them. The papers were not read at the Congress, but 99 written communications, covering nearly every subject under consideration, had been received and served to introduce the oral discussion. Since the date of the Congress 23 additional written communications have been received. Full details of the attendance, number of meetings, papers, etc., at the Congress have already been published.

The Board wishes here to express its appreciation of the faithful and successful work performed by the regular staff of the Society, in connection with the Congress, without which it would have been impossible to have accomplished such a result. The ordinary work of the Society has gone on as usual, there having been no interruption of the regular issues of *Proceedings, Transactions,* Blue Lists, Ballots, etc.; the regular semi-monthly meetings, with the exception of that for October 1st, have been held; and, in addition to this, for a period of 4 months or more, additional engineering papers averaging more than 10 000 words each, many of them illustrated, were issued in advance form at the rate of three papers every four days.

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* *Proceedings*, November, 1904.

The work of preparing discussions is now in progress, is as well advanced as could be expected, and it is hoped to have the whole Congress Publication ready for issue during the next six months.

FINANCES.

The attention of Members is invited to the Secretary's statement of receipts and disbursements, and to the general balance sheet which accompanies it, in which the very satisfactory financial condition of the Society appears. That condition may be emphasized by pointing out that, although there has been no change in the regular work or literary output, as stated elsewhere in this Report, and although there has been paid an additional interest charge of $3 243.61, due to the increased mortgage debt, and an extraordinary expenditure of $17 579.27 on account of the St. Louis Headquarters and the International Engineering Congress, the balance on hand at the end of the fiscal year (after deducting $18 034.22 cash received on account of new mortgage) is $5 002.73 greater than it was one year ago.

The reports of the Secretary and the Treasurer are appended.

By order of the Board of Direction.

CHAS. WARREN HUNT.
Secretary.

NEW YORK, January 3d, 1905.

GENERAL BALANCE SHEET, DECEMBER 31st, 1904.

Accompanying the Report of the Secretary.

Assets.		
Three Lots (estimated value)		$255 000.00
Society Building (cost)		103 597.83
Furniture (cost)		16 333.44
Publications on hand (inventoried cost, value)		15 391.11
Library:		
Cash expended for Books, etc.	$9 533.46	
Donations, estimated value.	44 760.06	
		54 293.52
Due from Members	$2 064.73	
" " Non-Members	340.33	
		2 405.06
Cash		49 927.49
		$496 948.45

Liabilities.		
Dues for 1905, paid in advance		$16 639.30
Mortgage Debt		175 000.00
*Funds invested in Society House, Lots and Library.	$26 405.78	
Surplus	278 903.37	
		305 309.15
		$496 948.45

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* These Funds have been derived from the following sources:

Norman Medal Fund	$1 000.00
Rowland Prize Fund	1 222.50
Collingwood Prize Fund	1 000.00
McCrea Swift Fund	1 000.00
Herbert Stewart Library Fund	1 940.00
Fellowship Fund	13 038.28
Compounding Dues Fund	7 205.00
	$26 405.78

The Norman Medal, Rowland Prize and Collingwood Prize Funds no longer exist as such, the obligations under them having been assumed by the Society, with the consent of the donors.

REPORT OF THE SECRETARY, FOR THE

To the Board of Direction of the

Gentlemen:—I have the honor to present a statement of Re-
December 31st, 1904. I also append a general balance sheet show-
New York, January 3d, 1905.

Receipts.

Balance on hand December 31st, 1903, in Bank, Trust Company and in hands of Treasurer		$26 890.54
Entrance Fees	$8 275.00	
Current Dues	35 684.24	
Past Dues	1 210.00	
Advance Dues	16 639.30	
Certificates of Membership	354.75	
Badges	1 715.30	
Sales of Publications	2 660.97	
Advertisements	30.00	
Interest	1 156.13	
Compounding Dues	840.00	
Library	83.70	
Annual Meeting	480.00	
Binding	3 271.48	
Bond and Mortgage	175 000.00	
Entertainment of British Engineers	2 243.75	
International Engineering Congress	2 615.15	
Miscellaneous	49.23	
		252 489.00
		$279 379.54

YEAR ENDING DECEMBER 31st, 1904.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

ceipts and Disbursements for the fiscal year of the Society, ending
ing the condition of the affairs of the Society.

Respectfully submitted,

CHAS. WARREN HUNT,
Secretary.

DISBURSEMENTS.

Salaries of Officers	$8 475.00	
Clerical Help	11 101.88	
Caretaking	1 770.36	
Publications	13 028.11	
Postage	3 541.01	
General Printing and Stationery	1 963.01	
Badges	1 429.85	
Certificates of Membership	193.80	
Binding	1 774.94	
Library	976.43	
Maintenance of House	263.08	
Heat, Light and Water	1 097.36	
Betterments	37.00	
Furniture	100.80	
Annual Meeting	933.36	
International Engineering Congress	13 579.27	
Prizes	111.00	
Advertising Commissions	18.52	
Interest and Insurance	5 933.61	
Bond and Mortgage	55 000.00	
Entertainment of British Engineers	2 151.25	
Building and Lot	101 095.50	
Current Business	689.93	
Louisiana Purchase Exposition	4 000.00	
Petty Expenses	186.98	
		$229 452.05
Balance on hand December 31st, 1904:		
In Union Trust Company	$42 448.35	
In Garfield National Bank	6 494.14	
In hands of Treasurer	985.00	
		49 927.49
		$279 379.54

REPORT OF THE TREASURER.

In compliance with the provisions of the Constitution, the Treasurer presents the following report for the year ending December 31st, 1904:

Balance on hand December 31st, 1903			$26 890.54
Receipts from current sources, January 1st to December 31st, 1904			72 630.10
Extraordinary receipts on account of Additional Mortgage			175 000.00
Extraordinary receipts on account of Inter. Eng. Congress and Entertainment of British Engineers			4 858.90
Payments on audited vouchers for current business, January 1st to December 31st, 1904		$53 626.03	
Extraordinary expenses on account of Purchase of Lot and Paying off old Mortgage		156 095.00	
Extraordinary expenses on account of International Engineering Congress, St. Louis Exhibit and Headquarters, and Entertainment of British Engineers		19 730.52	
Balance on hand December 31st, 1904:			
In Union Trust Company	$42 448.35		
In Garfield National Bank	6 494.14		
In hands of Treasurer	985.00		
		49 927.49	
		$279 379.54	$279 379.54

Respectfully submitted,

JOS. M. KNAP,

Treasurer, Am. Soc. C. E.

New York, January 3d, 1905.

ACCESSIONS TO THE LIBRARY.

December 14th, 1904, to January 10th, 1905.

DONATIONS.*

PRODUCER GAS.

A Sketch of the Properties, Manufacture and Uses of Gaseous Fuel. By Humboldt Sexton. Cloth, 9 x 6 in., 8 + 214 + 6 pp., Illus., Manchester, The Scientific Publishing Company. 10 shillings net.

In 1902 the author gave a course of lectures on producer gas at the Technical College, Glasgow, and it was requested that they be published. This little book is based on the notes of the lectures. The author states that special attention has been given to the principles on which the production of gaseous fuel depends, as once these are mastered the practical questions as to the best form and design of producer are quite simple. Typical producers have been described, and in an appendix some of the latest forms. Patented gas producers are numerous, and many of them involve no new principle or even important improvement in detail, but it is advantageous to the student and the practical man to know what has been done. Many important branches are not touched—as, for instance, domestic heating—as to have dealt with them satisfactorily would have increased the size of the book far beyond what is desirable. For the same reason other topics are dealt with very briefly. There is an index of six pages.

ORDINARY FOUNDATIONS.

Including the Coffer-Dam Process for Piers with Numerous Practical Examples from Actual Work. By Charles Evan Fowler, M. Am. Soc. C. E. Second Edition, Revised and Enlarged. Cloth, 9 x 6 in., illus, 26 + 314 pp. New York, John Wiley & Sons. London, Chapman & Hall, Limited, 1905. $3.50.

The preface states that it is hoped in enlarging the field covered by "The Coffer-Dam Process for Piers," the book will be more valuable for the practical engineer, besides giving a sufficiently general treatment to make it valuable for class work. The necessity for a second edition has rendered it possible to make additions to the text, by which the subject of ordinary foundations is more comprehensively covered. The construction of piers by the use of metal cylinders; with timber caissons by open dredging; and the construction of foundations of ordinary size by the use of pneumatic caissons, has furnished another chapter. A chapter has been added which covers the bearing capacity of soils. The new chapter on building stone, masonry and the design of piers is intended to supplement the old chapter on the "Location and Design of Piers." New matter has been added on cement and concrete, which includes tables giving the quantity of material required for concrete of different proportions. The building of piers and pile bents and timber preservation have been discussed. There is an index of seventeen pages.

Gifts have also been received from the following:

Altoona—City Clerk. 1 bd. vol.
Am. Ceramic Soc. 1 vol.
Am. Inst. of Min. Engrs. 1 pam.
Am. Street Ry. Assoc. 1 pam.
Arizona Univ.—Agri. Exper. Station 1 pam.
Carpenter, L. G. 1 pam.
Conn. R. R. Commrs. 1 bd. vol.
Cornell Univ. Lib. 1 pam.
Deutsch-Am. Tech.-Verband. 1 pam.
Eidlitz, Marc & Son. 1 bd. vol.
Farley, G. P. 12 vol.
Fisk, W. L. 2 pam., 4 maps.
Illinois Steel Co. 2 pams.
Inst. of Civ. Engrs. 1 bd. vol., 1 pam.
Liverpool—Engr. of Water Works. 1 pam.
Madras—Pub. Works Dept. 1 pam.
Maryland Geol. Surv. 6 bd. vol., 1 pam.
Mass. Inst. of Tech. 1 vol.
Mass.—State Board of Health. 1 bd. vol.
Mich.—State Board of Health. 4 pam.
Moore, Robert. 1 pam.
New Haven—Shell-Fish Comm. 1 pam.
New South Wales—Govt. Statistician. 9 bd. vol.
New South Wales—Ry. Commrs. 1 bd. vol.
New York City Record. 3 bd. vol.
N. Y. Univ. 1 vol.
Ohio.—Geol. Surv. 1 bd. vol.
Royal Phil. Soc. of Glasgow. 21 vol.
Seafert, Wm. 1 pam.
Sperry, H. M. 2 bd. vol., 22 pam.
Thayer School of Civ. Eng. 1 pam.
Timonoff, V. E. 1 vol.
Tonindustrie Zeitung. 1 bd. vol., [illegible] vol.
Union Switch and Signal Co.

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* Unless otherwise specified, books in this list have been donated by the p

U. S. Bureau of Statistics. 1 vol.
U. S. Coast and Geodetic Survey. 1 pam.
U. S. Div. of Foreign Markets. 1 pam.
U. S. Engrs. School of Application. 2 pam.
U. S. Geol. Surv. 1 bd. vol., 6 vol., 1 pam.
U. S. Interstate Commerce Comm. 1 pam.
U. S. Library of Congress. 1 bd. vol.
U. S. Navy Dept. 10 pam.
Univ. of Texas Mineral Surv. 2 vol.
Unknown. 13 bd. vol., 5 pam
Western Australia—Commr. of Rys. 1 pam.

BY PURCHASE.

Mineral Industry during 1903. Vol. 12. Founded by R. P. Rothwell. Prepared by the Editorial Staff of *The Engineering and Mining Journal.* The Work on this Volume has been more Particularly under the Supervision of D. H. Newland. New York, *Engineering and Mining Journal,* 1904.

Elektrotechnik in Einzeldarstellungen. Heft V. Die Asynchronen Drehstrommotoren ihre Wirkungsweise, Prüfung und Berechnung. Von Gustav Benischke. Braunschweig, Friedrich Vieweg und Sohn, 1904.

Journal of Gas Lighting. Vols. 85-88. London, Walter King, 1904.

SUMMARY OF ACCESSIONS.

December 14th, 1904, to January 10th, 1905.

Donations (including 14 duplicates)	165
By purchase	3
Total	168

MEMBERSHIP.

ADDITIONS.

MEMBERS.

		Date of Membership.
Fortin, Sifroy Joseph. Representing Milliken Bros., Apartado 2019, City of Mexico, Mexico.	Assoc. M. M.	Nov. 6, 1895 Dec. 6, 1904
Gardner, William Montgomery. U. S. Asst. Engr., U. S. Engr.'s Office, Memphis, Tenn		Dec. 7, 1904
Hatch, James Noble. Structural Engr. with Sargent & Lundy, 1720 Railway Exchange, Chicago, Ill		Dec. 7, 1904
Merritt, David Spencer. 10 N. Broadway, Tarrytown, N. Y.		Jan. 4, 1905
Nuebling, Emil Louis. Supt. and Engr., Dept. of Water, Reading, Pa.		Dec. 7, 1904
Van Cleve, Aaron Howell. Res. Engr., The Niagara Falls Power Co. and allied companies, Niagara Falls, N. Y.; Res. Engr., Canadian Niagara Power Co., Niagara Falls, Ont.; Address, Niagara Falls, N. Y	Jun. Assoc. M. M.	May 31, 1892 Dec. 5, 1894 Nov. 1, 1904
Wallace, Harold Ulmer. Chf. Engr., Ill. Cent. R. R., Hotel Windemere, 56th and Cornell Ave., Chicago, Ill.		Dec. 7, 1904
Watson, Wilbur Jay. Bridge Engr., The Osborn Eng. Co., Osborn Bldg., Cleveland, Ohio.	Jun. Assoc. M. M.	Oct. 4, 1898 Jan. 2, 1901 Jan. 3, 1905
Wheeler, Edgar True. 661 Pacific Elec. Bldg., Los Angeles, Cal.		Dec. 7, 1904
Wilson, Everett Broomall. Secy. and Treas. of The Am. Bureau of Inspection and Tests, Monadnock Blk., Chicago (Res., 1408 Dempster St., Evanston), Ill	Assoc. M. M.	Mar. 4, 1903 Dec. 6, 1904

ASSOCIATE MEMBERS.

Barnes, Fred Asa. Instr. in Civ. Eng., Cornell Univ., 324 Huestes St., Ithaca, N. Y		Dec. 7, 1904
Keim, Warren Byron. 129 N. 4th St., Harrisburg, Pa		Jan. 4, 1905
Lucas, George Latimore. Res. Engr., Castlegould, Port Washington, D. C		Dec. 7, 1904
Scheuermann, Hugo Julius. Bridge Designer, Barge Canal Office, Albany, N. Y		Dec. 7, 1904
Tucker, Herman Franklin. Room 1107, Exchange Bldg., Boston, Mass		Dec. 7, 1904
Turner, Willis Tubbs. Box S, Salt Lake City, Utah		Dec. 7, 1904
White, Frank George. Chf. Draftsman, Office of City Engr., Salt Lake City, Utah.	Jun. Assoc. M.	Dec. 3, 1901 Dec. 7, 1904

	Date of Membership.
Wright, Joseph. Wyanet, Ill	Dec. 7, 1904
Zorn, George Washington. Cody, Wyo	Dec. 7, 1904

JUNIORS.

Brown, Alfred Thomas. 2005 Washington Ave., New York City.	Nov. 1, 1904
Edwards, Dean Gray. 430 West 118th St., New York City.	Nov. 1, 1904
Goddard, Herbert Willard. Technology Club, 36 East 28th St., New York City	Jan. 3, 1905
Hanavan, William Lawrence. 430 West 118th St., New York City	Dec. 6, 1904
Howe, Harry Northrop. U. S. Engr. Office (Box 204), Memphis, Tenn.	Dec. 6, 1904
Spencer, Herbert. Div. Engr.'s Office, Syracuse, N. Y.	Feb. 2, 1904
Walker, George Johnson. Draftsman with Am. Bridge Co., 316 Thorn St., Sewickley, Pa	Dec. 6, 1904

RESIGNATIONS.

MEMBERS.

Anderson, Latham	Dec. 31, 1904
Boehmer, Max	Dec. 31, 1904
Taylor, Norton Longstreth	Dec. 31, 1904

ASSOCIATE MEMBERS.

Despard, Duncan Lee	Dec. 31, 1904
Noyes, Harry Lincoln	Dec. 31, 1904

JUNIORS.

Brisley, Edward Betts	Dec. 31, 1904
Hall, Frederic Francis	Dec. 31, 1904
Hopkins, George Gallagher, Jr	Dec. 31, 1904

DEATHS.

Crosby, Wilson	Elected Member, September 15th, 1869; died December 18th, 1904.
Cunningham, John Miller	Elected Associate Member, October 7th, 1903; died August 8th, 1904.
Myers-Beswick, William Beswick	Elected Member, January 3d, 1894; died December 27th, 1904.
Looker, Henry Brigham	Elected Associate Member, May 3d, 1893; died January 3d, 1905.

MONTHLY LIST OF RECENT ENGINEERING ARTICLES OF INTEREST.

(December 12th, 1904, to January 7th, 1905.)

NOTE.—*This list is published for the purpose of placing before the members of the Society the titles of current engineering articles, which can be referred to in any available engineering library, or can be procured by addressing the publication directly, the address and price being given wherever possible.*

LIST OF PUBLICATIONS.

In the subjoined list of articles references are given by the number prefixed to each journal in this list.

(1) *Journal*, Assoc. Eng. Soc., 257 South Fourth St., Philadelphia, Pa., 30c.
(2) *Proceedings*, Engrs. Club of Phila., 1122 Girard St., Philadelphia, Pa.
(3) *Journal*, Franklin Inst., Philadelphia, Pa., 50c.
(4) *Journal*. Western Soc. of Engrs., Monadnock Block, Chicago, Ill.
(5) *Transactions*, Can. Soc. C. E., Montreal, Que., Canada.
(6) *School of Mines Quarterly*, Columbia Univ., New York City, 50c.
(7) *Technology Quarterly*, Mass. Inst. Tech., Boston, Mass., 75c.
(8) *Stevens Institute Indicator*, Stevens Inst., Hoboken, N. J., 50c.
(9) *Engineering Magazine*, New York City, 25c.
(10) *Cassier's Magazine*, New York City, 25c.
(11) *Engineering* (London), W. H. Wiley, New York City, 25c.
(12) *The Engineer* (London), International News Co., New York City, 35c.
(13) *Engineering News*, New York City, 15c.
(14) *The Engineering Record*, New York City, 12c.
(15) *Railroad Gazette*, New York City, 10c.
(16) *Engineering and Mining Journal*, New York City, 15c.
(17) *Street Railway Journal*, New York City, 35c.
(18) *Railway and Engineering Review*, Chicago, Ill., 10c.
(19) *Scientific American Supplement*, New York City, 10c.
(20) *Iron Age*, New York City, 10c.
(21) *Railway Engineer*, London, England, 25c.
(22) *Iron and Coal Trades Review*, London, England, 25c.
(23) *Bulletin*, American Iron and Steel Assoc., Philadelphia, Pa.
(24) *American Gas Light Journal*, New York City, 10c.
(25) *American Engineer*, New York City, 20c.
(26) *Electrical Review*, London, England.
(27) *Electrical World and Engineer*, New York City, 10c.
(28) *Journal*, New England Water-Works Assoc., Boston, $1.
(29) *Journal*, Society of Arts, London, England, 15c.
(30) *Annales des Travaux Publics de Belgique*, Brussels, Belgium.
(31) *Annales de l'Assoc. des Ing. Sortis des Ecole Speciales de Gand*, Brussels, Belgium.
(32) *Memoires et Compte Rendu des Travaux*, Soc. Ing. Civ. de France, Paris, France.
(33) *Le Genie Civil*, Paris, France.
(34) *Portefeuille Economique des Machines*, Paris, France.
(35) *Nouvelles Annales de la Construction*, Paris, France.
(36) *La Revue Technique*, Paris, France.
(37) *Review de Mecanique*, Paris, France.
(38) *Revue Generale des Chemins de Fer et des Tramways*, Paris, France.
(39) *Railway Master Mechanic*, Chicago, Ill., 10c.
(40) *Railway Age*, Chicago, Ill., 10c.
(41) *Modern Machinery*, Chicago, Ill., 10c.
(42) *Transactions*, Am. Inst. Elect. Engrs., New York City, 50c.
(43) *Annales des Ponts et Chaussées*, Paris, France.
(44) *Journal*, Military Service Institution, Governor's Island, New York Harbor, 50c.
(45) *Mines and Minerals*, Scranton, Pa., 20c.
(46) *Scientific American*, New York City, 8c.
(47) *Mechanical Engineer*, Manchester, England.
(48) *Zeitschrift*, Verein Deutscher Ingenieure, Berlin, Germany.
(49) *Zeitschrift für Bauwesen*, Berlin, Germany.
(50) *Stahl und Eisen*, Düsseldorf, Germany.
(51) *Deutsche Bauzeitung*, Berlin, Germany.
(52) *Rigasche Industrie-Zeitung*, Riga, Russia.
(53) *Zeitschrift*, Oesterreichischer Ingenieur und Architekten Verein, Vienna, Austria.
(54) *Transactions*, Am. Soc. C. E., New York City, $5.

(55) *Transactions,* Am. Soc. M. E., New York City, $10.
(56) *Transactions,* Am. Inst. Min. Engrs., New York City, $5.
(57) *Colliery Guardian,* London, England.
(58) *Proceedings,* Eng. Soc. W. Pa., 410 Penn Ave., Pittsburg, Pa., 50c.
(59) *Transactions,* Mining Inst. of Scotland, London and Newcastle-upon-Tyne, England.
(60) *Municipal Engineering,* Indianapolis, Ind., 25c.
(61) *Proceedings,* Western Railway Club, 225 Dearborn St., Chicago, Ill., 25c.
(62) *American Manufacturer and Iron World,* 59 Ninth St., Pittsburg, Pa.
(63) *Minutes of Proceedings,* Inst. C. E. London, England.
(64) *Power,* New York City, 20c.
(65) *Official Proceedings,* New York Railroad Club, Brooklyn, N. Y., 15c.
(66) *Journal of Gas Lighting,* London, England, 15c.
(67) *Cement and Engineering News,* Chicago, Ill., 25c.
(68) *Mining Journal,* London, England.
(69) *Mill Owners,* New York City, 10c.
(70) *Engineering Review,* New York City, 10c.
(71) *Journal,* Iron and Steel Inst., London, England.
(72) *Street Railway Review,* Chicago, 30c.
(73) *Electrician,* London, England, 18c.
(74) *Transactions,* Inst. of Min. and Metal., London, England.
(75) *Proceedings,* Inst. of Mech. Engrs., London, England.
(76) *Brick,* Chicago, 10c.
(77) *Journal,* Inst. Elec. Engrs., London, England.
(78) *Beton und Eisen,* Vienna, Austria.
(79) *Forscherarbeiten,* Vienna, Austria.
(80) *Tonindustrie-Zeitung,* Berlin, Germany.
(81) *Zeitschrift fur Architektur und Ingenieurwesen.* Wiesbaden, Germany.
(82) *Dinglers Polytechnisches Journal,* Berlin, Germany.

LIST OF ARTICLES.

Bridge.

The Jubilee Bridge over the River Hooghly.* Kenneth Smale Laurie. (63) Vol. 158.
Axle-Loads on Railway Bridges.* John Graham. (63) Vol. 158.
Maximum Bending-Moment in a Girder under a Moving Group of Loads.* Evelyn Henry Young. (63) Vol. 158.
Concrete-Steel Arches on the Indianapolis Northern Traction Lines.* (72) Dec.
The Erection of the New Ferry Bridge at Duluth, Minn.* (13) Dec. 15; (46) Dec. 24.
The Anchorages for the Manhattan Bridge at New York City.* (15) Dec. 16; (14) Dec. 17; (13) Dec. 22.
Scherzer Bridge for the Newburgh & South Shore.* (15) Dec. 16; (40) Dec. 16.
The Cuyahoga River Rolling-Lift Bridge.* (14) Dec. 17.
The Schell Memorial Bridge.* (14) Serial beginning Dec. 17.
Rapid Railway Trestle Building. A. S. Zinn. (14) Dec. 17.
Details at the Pivot Pier and Ends of the Merrimac River Drawbridge, Newburyport, Mass.* (14) Dec. 17.
Concrete-Steel Bridge at Plano, Ill.; Chicago, Burlington & Quincy Ry.* (13) Dec. 22.
The Erection of the Rondout Bridge.* (14) Dec. 24.
The Expansion Joints of the Thebes Bridge.* (14) Dec. 24.
The Illumination of the Williamsburg Bridge, New York City.* (27) Dec. 24.
Erecting a Plate Girder Bridge With a Gin Pole.* J. W. Philips. (15) Dec. 30.
Tie for Concrete Forms.* M. H. M'Gee. (15) Dec. 30.
The Proposed Hendrik Hudson Memorial Bridge.* (14) Dec. 31.
The Stone Bridge at Hartford, Conn.* (14) Dec. 31.
A Skew-Arch of Concrete Steel. (60) Jan.
The Charleston Bridge Failure.* H. G. Tyrrell. (13) Jan. 5.
The New Newark Bay Bridge: A Tandem Scherzer Rolling Lift Bridge.* S. D. V. Burr. (20) Jan. 5.
A Difficult Piece of Bridge Erection in Connection with Terminal Improvements of the New York Central & Hudson River R. R. Co.* Frank C. Shepherd, Assoc. M. Am. Soc. C. E. (13) Jan. 5.
Allgemeine Berechnung der Normal- und Schubspannungen in Trägern aus Eisenbeton.* Dr. Saliger. (78) Pt. 5, 1904.
Dimensionierung der T-förmigen Träger.* Max R. v. Thullie. (78) Pt. 5, 1904.
Bogenbalken, System Thrul.* Fritz v. Emperger. (78) Pt. 5, 1904.
Einige Besondere Arten von Brückenträgern.* V. v. Friedrichs. (52) Nov. 30.
Beitrag zur Berechnung der Querrahmen Eiserner Brücken.* F. Brunner. (53) Dec. 9.
Versuche mit Sandsteinquadern zu Brückengelenken.* C. Bach. (48) Dec. 17.
Zum Wettbewerb zur Erlangung von Entwürfen für die Neue Rheinbrücke bei Ruhrort.* (51) Serial beginning Dec. 21.

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* Illustrated.

Electrical.

A Notable Electric Power Station.* (8) Oct.
A Protest on Behalf of Wattless Current.* E. J. Willis. (8) Oct.
Switchboard Design.* A. S. Loizeaux. (8) Oct.
Deltabeston Magnet Wire. (72) Dec.
Problems of Heavy Electric Traction.* O. S. Lyford, Jr., and W. N. Smith. (42) Dec.
The Maximum Distance to Which Power can be Economically Transmitted.* Ralph D. Mershon. (42) Dec.
Electric Power Distribution in South Wales.* (73) Serial beginning Dec. 2.
Two Scottish Electric Power Schemes.* (73) Dec. 2.
Electric Power at the *Scotsman* Offices. (73) Dec. 2.
Comparative Designs for a 10-KW Dynamo.* J. W. Burleigh. (26) Dec. 9.
Pietermaritzburg (Natal) Electric Lighting and Tramways.* (26) Dec. 9.
Some New Electricity Meters.* (73) Dec. 9.
The Home Office Draft Regulations for the Use of Electricity in Factories and Workshops. Frank Broadbent, M. I. E. E. (26) Dec. 9.
The "Megger." (73) Dec. 9.
Proposed Electrification of Railways in South Australia. (73) Dec. 9.
An Electrolytic Wireless Telegraph Detector.* James E. Ives. (27) Dec. 10.
The Predetermination of Plunger Electromagnets.* Silvanus P. Thompson. (Paper presented at the International Elec. Cong.) (27) Dec. 10.
The Chicago Telephone Company's "Juice Wagon."* (27) Dec. 10.
The Pollak-Virag Rapid Telegraph.* (12) Dec. 16; (47) Dec. 17.
The Magnetic Resistance of Air-Gaps.* G. Benischke. (From *Electrotechnische Zeitschrift.*) (26) Dec. 16.
The Dielectric Strength of Certain Specimens of Mica.* Ernest Wilson and W. H. Wilson. (73) Dec. 16.
Notes on Experiments with Transformers for Very High Potentials.* Harold B. Smith. (Abstract of Paper read before the International Elec. Cong.) (73) Dec. 16.
Loaded Telephone Lines in Practice.* Hammond Vinton Hayes. (Paper read before the International Elec. Cong.) (73) Dec. 16.
The St. Louis Exhibition: The Exhibits of the Allis-Chalmers-Bullock Companies. (11) Dec. 16.
The Advantages of the Electric Drive.* D. N. Dunlop. (22) Dec. 16.
General Proportions of the Mechanical Equipment of the Arthur Building, New York.* (14) Dec. 17.
The Power Plant of the Oliver Building, Boston. Howard S. Knowlton. (14) Dec. 17.
The Manufacture of Carbons in England.* Frank C. Perkins. (19) Dec. 17.
Typical New Telephone Building at Newton, Mass. (27) Dec. 17.
Simple German Instruments for Testing the Magnetic Properties of Iron.* (19) Dec. 17.
Development of Electric Power Behind Niagara Falls.* (27) Dec. 17.
Fundamental Principles of Power Equipment for Telephone Exchanges. B. D. Willis. (27) Dec. 17.
Special Methods for Locating Faults on Electric Cables.* Henry W. Fisher. (27) Dec. 17.
On the Theory of the Regulation of Alternators.* C. F. Guilbert. (27) Dec. 17.
Recent Station Equipment of the Worcester Electric Light Co., Worcester, Mass. (27) Dec. 17.
The Combination of Dust Destructors and Electricity Works Economically Considered.* Frank Broadbent. (26) Dec. 23.
Some New Switches and Fuses.* (26) Dec. 23.
Motor Speed Controller.* (12) Dec. 23.
Water-Power *v.* Steam-Power in the British Isles. E. Ristori, Assoc. M. Inst. C. E. (11) Dec. 23.
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Vol. XXXI. JANUARY, 1905. No. 1.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PAPERS AND DISCUSSIONS.

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THE WATER-WORKS OF PORTERVILLE, CALIFORNIA.

By Philip E. Harroun, M. Am. Soc. C. E.

To be Presented February 15th, 1905.

The engineer finds available much descriptive matter and many data as to the cost of systems of water-works of magnitude, but for those systems supplying small towns and cities little is to be had. For this reason it is believed that a description of the Porterville Water-Works, together with some notes on their operation, will prove of interest to the Profession, not only in the details of design and construction, but especially in the detailed items of cost. These latter items are especially interesting in showing the unit cost of construction and station expense under such conditions, and the large proportional general and organization charge against the plant.

For such small systems it is usually difficult to find reputable contractors, experienced in this class of work, who are willing to execute the work as a whole, and if an attempt is made to let the various details by contract, the difficulties are greatly increased. In either case the contractor has to meet the same general charges as

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Note.—These papers are issued before the date set for presentation and discussion. Correspondence is invited from those who cannot be present at the meeting, and may be sent by mail to the Secretary. Discussion, either oral or written, will be published in a subsequent number of *Proceedings*, and, when finally closed, the papers, with discussion in full, will be published in *Transactions*.

those which would apply to the construction of a system of much greater magnitude, and, in addition, feels justified in asking a net percentage of profit inversely proportional to the cost of the system. Under such circumstances, the engineer frequently finds it advantageous to undertake the construction of the system by company work, especially where the character of the structures proposed requires care in their execution, and, consequently, a careful supervision. These considerations, particularly the latter, controlled in the decision to construct the Porterville system by company work.

The plans were prepared by Arthur L. Adams, M. Am. Soc. C. E., and the plant was built complete by the writer.

THE OLD SYSTEM.

Porterville is situated in the orange belt at the southeastern edge of the San Joaquin Valley, California, and has an estimated population of from 1 800 to 2 000. The water supply was drawn from a bored and cased 12-in. well, 196 ft. deep, passing through from 10 to 12 ft. of surface drift, thence through seamed or laminated clay separated by thin water-bearing gravel strata, to the source of supply, a gravel stratum some 10 ft. thick.

The pump was a 6-in. compound centrifugal, placed horizontally at the bottom of a 6 by 8-ft. timber-lined shaft, 25 ft. deep, and was direct-connected to a 30 h. p., 200-volt, 2-phase motor running at a speed of 850 rev. per min. on a vertical shaft 20 ft. above the pump, the pump motor and shaft being held within a light, four-post, structural-steel tower.

Current was supplied by the Mt. Whitney Power Company at $50 per horse-power per annum for continuous use, this rate being based on the maximum amount of power consumed. The pump was operated continuously, and delivered 360 gal. per min. against a dynamic head of 153 ft. Measurement of current by the Mt. Whitney Power Company showed a consumption of 38 h. p., giving a combined efficiency of about 35% for the plant.

The system in use was pumping direct, and to storage and equalizing tanks. These tanks, of which there were two of 30 000 gal. each, were of 3-in. timber staves, and were supported on a low timber tower upon a knoll 4 800 ft. east of the town and the pumping plant.

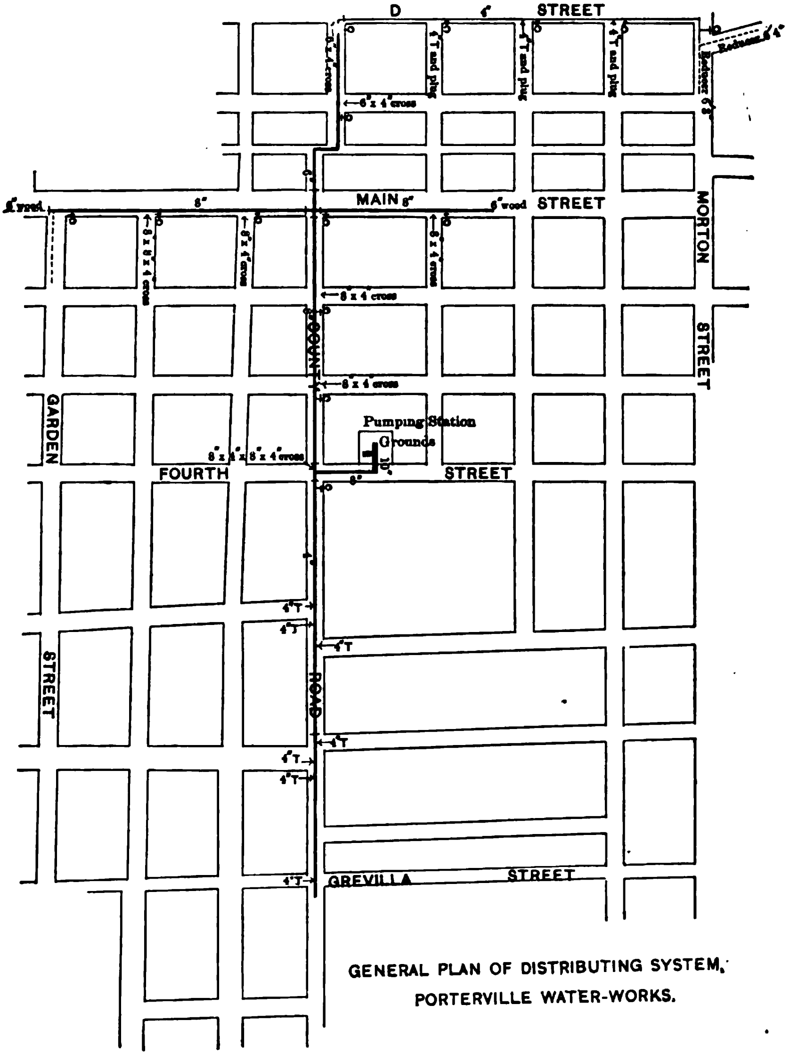
The distribution system consisted of 6 499 ft. of 6-in. riveted steel pipe, No. 16 gauge; 1 359 ft. of 6-in., 721 ft. of 4-in. and 4 403 ft. of 3-in. spiral-wound, wooden stave pipe; 2 140 ft. of 3-in. and 9 842 ft. of 2-in. standard screw pipe. All services, of which there were 215, were of ¾-in. screw pipe. Fire hydrants fitted for 2½-in. hose connections were distributed throughout the business and principal residence sections, and in many instances were taken from 2-in. street mains. The efficiency of the fire service can better be imagined than described.

The riveted steel pipe was second-hand when laid in 1889, and became so badly corroded that in 1892 it was cased in from 4 to 6 in. of sand concrete. The standard screw pipe has been in service since 1889, and is in fair condition, considering its life, but is badly corroded in places. The spiral-wound, wooden stave pipe was laid during the spring of 1902, and the steel-wire winding shows corrosion where its asphaltum coating has been injured. Services were so badly corroded that in many cases the metal had disappeared and the water was carried by a rust-cemented sand shell 3 or 4 in. in diameter.

THE NEW SYSTEM.

The design for the new system proceeded on the assumption that sufficient funds could be expended for the construction of such works as were necessary to give, as a permanent investment, the most economic, and therefore the most profitable, results, regardless of first cost, it being assumed that the works should be designed with a view of affording a degree of fire protection suited to the needs of a town of from 2 000 to 8 000 people, direct from the hydrants, with the possibility of suitable increase should the growth of Porterville in the future require it. (Fig. 1.)

This policy, however, could not be carried out in full, and, after construction was begun, curtailment of funds available for the plant caused a modification of the plans, the most noticeable being a reduction in the capacity of the elevated tank from 100 000 to 75 000 gal.



GENERAL PLAN OF DISTRIBUTING SYSTEM, PORTERVILLE WATER-WORKS.

FIG. 1.

It was decided to continue the system of pumping direct and to storage, and to locate the elevated steel tank on the grounds at the pumping station. The old tanks were to be abandoned entirely as well as 2 600 ft. of the old 6-in. main supplying these tanks and adjoining them, there being no service connections within this section.

Fire service was to be pumpage direct into the mains at 100 lb. pressure, the elevated tank being cut off from the system by a gate at the pumping station.

Gas engines, operating on crude oil, were selected for power, instead of electricity or steam. In the case of electricity, the price asked by the Mt. Whitney Power Company, $50 per horse-power per annum, actually amounted to more than $100 per horse-power, on the basis of the maximum rate used. The resulting annual saving in operating expenses by the use of gas engines was estimated to be about $700, and the saving over the cost of steam power to be nearly as great.

The plant as designed consists of:

1.—A second well, adjacent to the first;

2.—A concrete-lined pump pit about the wells, oval in shape, 18 by 22 ft., on minor and major axes, and 25 ft. deep;

3.—An engine-house covered with galvanized corrugated iron for the housing of the engine plant;

4.—Pumping machinery in duplicate, consisting of two 9 by 12-in. triplex single-acting power pumps, each having a capacity of 500 gal. per min. at 100 lb. pressure, set on the bottom of the pump pit and belt-connected to two 32 h. p. gas engines; both engines and pumps to be operated coincidently only in case of fire;

5.—A concrete-lined reservoir of 100 000 gal. capacity adjoining the pumping plant, to supply one of the pumps in case of fire;

6.—A concrete-line fuel-oil storage tank of 7 000 gal. capacity;

7.—An elevated steel tower and tank of 75 000 gal. capacity;

8.—A system of cast-iron street mains, ranging in size

PLATE I.
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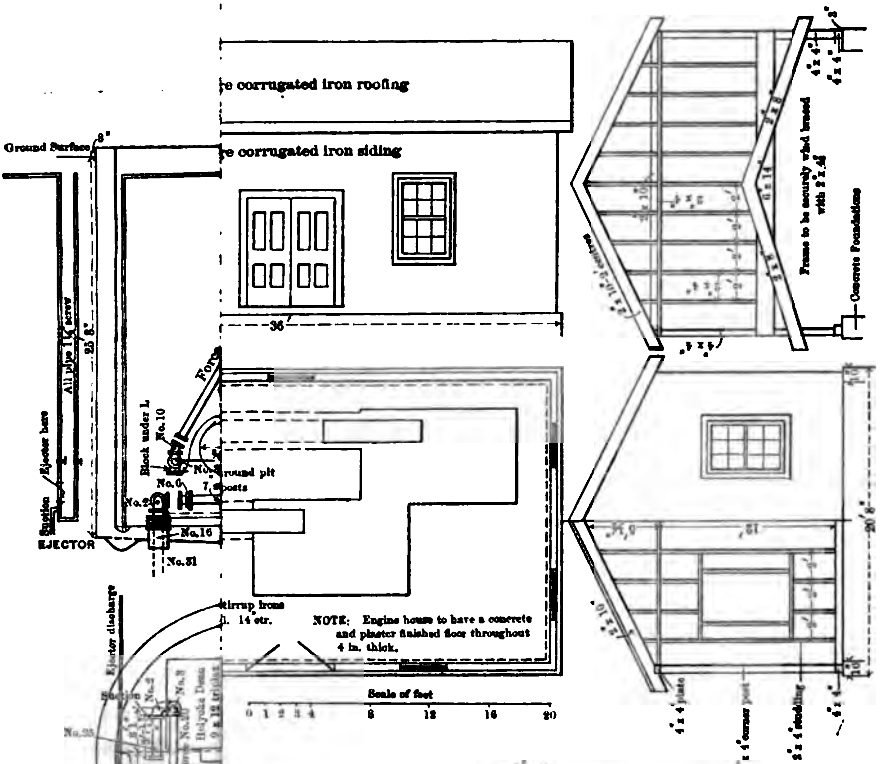
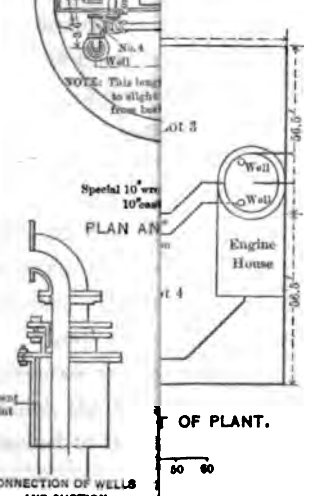
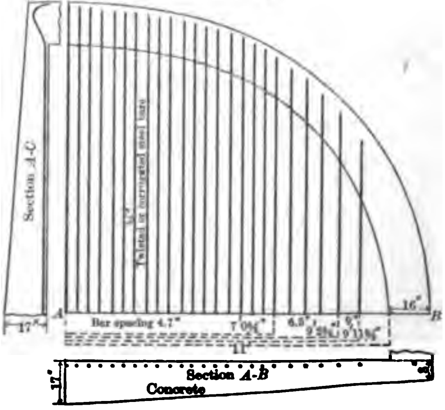
HARROUN ON
PORTERVILLE WATER-WORKS.





CONNECTION OF WELLS AND SUCTION.



PLAN AND SECTION, BOTTOM OF PUMP PIT.

from 8 to 4 in., the principal connections about the pumping station and elevated tank being 10 in. in size in anticipation of future need.*

Plates I and II and Figs. 1, 2, 3 and 4 show the general arrangement of the various structures as well as their details.

CONSTRUCTION.

To appreciate the local conditions affecting construction, it should be stated that Porterville is essentially a farming and fruit-raising community. There are no machine shops in the town, nor any facilities for handling pipe work larger than a 2-in. screw. The tools owned by the water-works consisted only of some half dozen picks and shovels. A "farmer's" blacksmith shop constituted the entire resource for any ironwork. All fittings and supplies, of whatever character, and screw-pipe work larger than 3-in., were obtained in San Francisco, 250 miles distant, and sent by freight. A cracked flange or a missing sleeve meant a delay of from eight to twelve days.

Common labor was scarce and unusually poor as a class. Skilled labor, with the exception of carpenters, was not to be had. The general wage paid was \$2 for common labor, \$3 to \$4.37½ for carpenters, \$4 for a foreman on pipe work, \$3 per day to \$90 and \$100 per month for a foreman on other work, all rates being on the basis of a 10-hour day.

The New Well.—No interest attaches to the drilling of the new well. The formation has been previously indicated. It was carried to a depth of 216 ft. and cased with single-riveted, steel, slip-joint, double casing, the inner casing of No. 14 gauge and the outer of No. 16 gauge, in 2-ft. lengths. It had been put down and perforated by the Water Company prior to the writer's assuming charge. Its cost is shown in Table 1.

Pump Pit.—In constructing the pump pit it was necessary to preserve without disturbance the centrifugal pump and motor upon which the town depended for its supply. Suspension rods were attached to the upper posts of the steel tower, and by these the pump, motor and piping were hung to timber girders which were supported by blocks outside of the pit excavation.

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* From Report of Arthur L. Adams, M. Am. Soc. C. E.

TABLE 1.—Cost of Well.

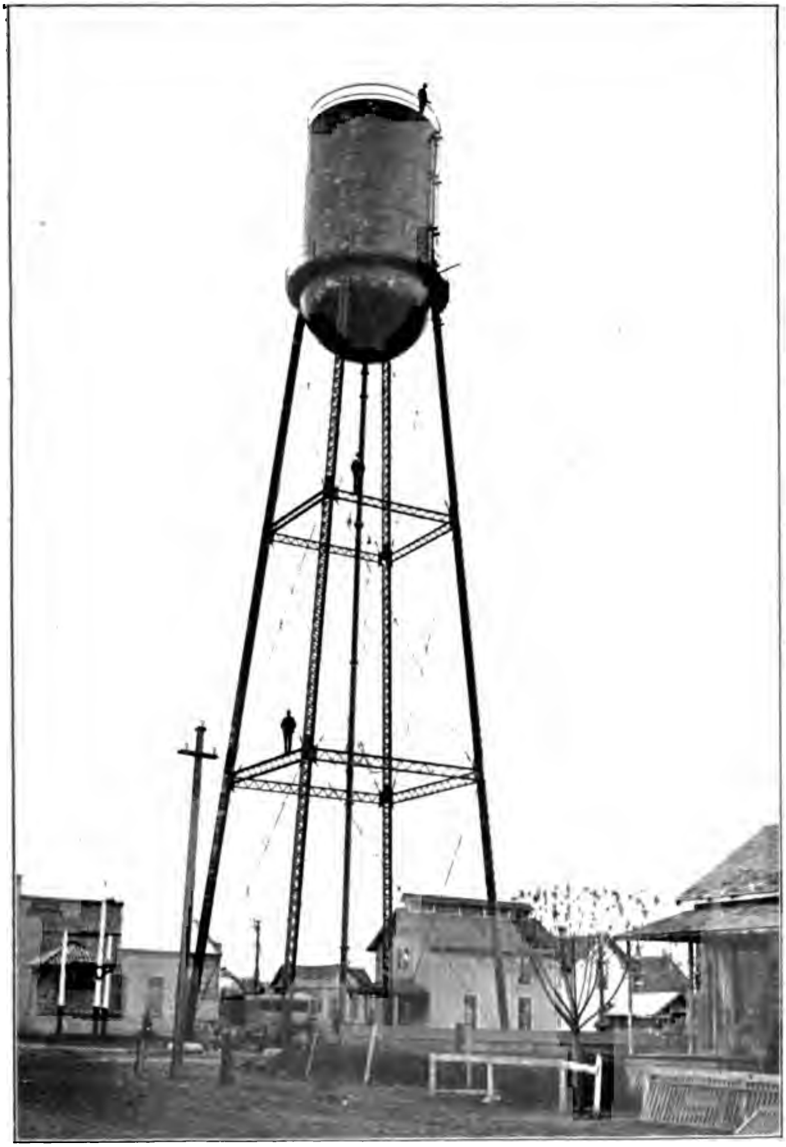
Drilling and driving casing,	200 ft.	at $2.00....	$400.00
" " " "	16 "	" 2.25....	36.00
Casing	216 "	" 1.03....	222.48
Perforating casing..........................			20.00
Testing well			22.50
Incidentals			16.57
Cost of well............................			$717.55

Excavation and Timbering.—The excavation was wholly by pick and shovel. To hoist the excavated material from the pit, a boom derrick was rigged. It handled two swing-bottom dump-boxes, each having a capacity of ½ cu. yd. One box was filled in the pit while the other was being hoisted by a two-mule team, and swung over a waiting wagon and dumped.

In sinking, the upper 7 or 8 ft. encountered consisted of adobe and river silt. Below this there were from 4 to 5 ft. of coarse gravel carrying a heavy volume of surface water. Underlying this water-bearing gravel there was clay to the bottom of the excavation. This clay was very hard to pick and move, and was filled with innumerable seams carrying water under pressure. Although the new well-casing had been perforated throughout this clay and surface-water section, and the city pump while in operation carried the water-table some 40 ft. below ground, yet the pressure of the water within the clay stratum was not relieved. The sides of the pit were covered with spouting streams, and the clay from which these emerged sloughed off badly, while the bottom of the pit was a series of small geysers. On account of this sloughing and caving, timbering became necessary from the surface down.

In timbering, ribs were constructed, 4 by 12-in. in section, oval in shape, 20 ft. 8 in. by 24 ft. 8 in. along the minor and major axes, so as to conform to the outside circumference of the pit concrete.

PLATE II.
PAPERS, AM. SOC. C. E.
JANUARY, 1905.
HARROUN ON
PORTERVILLE WATER-WORKS.



STEEL TOWER AND TANK FOR PORTERVILLE WATER-WORKS.

These ribs were braced radially by timbers ranging from 4 by 6 in. to 4 by 12 in. Outside these ribs 2 by 6-in. sheeting was driven vertically, the driving keeping pace with the sinking of the pit. The vertical spacing of the ribs was adjusted in accordance with the lateral pressure encountered, and the entire system was braced so as to prevent buckling.

During the excavation of the pit no special provision was made for handling the surface water. It had been reaching the city pump through the open 12-in. well at the bottom of the old shaft, and, during the sinking of the pit, it was disposed of in the same way. A slight turbidity in the city water was the only noticeable result.

The distributed cost of the pit and shaft excavation and timbering is given in Table 2.

TABLE 2.—Distributed Cost, Pit and Shaft Excavation, and Timbering.

Segregation.	Time.	Rate.	Total amount.	Cost per cubic yard. (453.9 cu. yd.)	
Excavation:					
Pick and shovel	1 238 hr.	20 cents.	$257.05	$0.5663	$0.8236
" " "	31½ "	30 "			
Miscellaneous labor	30 "	20 "	7.50	0.0165	
" "	5 "	30 "			
Team hoist	130 "	5 "	6.50	0.0143	
Tools and blacksmithing	....	....	65.32	0.1439	
Foreman	....	....	37.50	0.0826	
Timbering:					
Carpenter	72 hr.	37½ cents.	53.55	0.1179	$0.6658
"	88½ "	30 "			
Carpenter's helper	154½ "	20 "	30.90	0.0681	
Lumber (7 251 ft.)	....	....	161.39	0.3556	
Miscellaneous materials	....	....	18.88	0.0416	
Foreman	....	....	37.50	0.0826	
Cost of excavation and timbering			$676.04	$1.4894	$1.4894

The cost given in Table 2 covers the depositing of the excavated material in wagons at the edge of the pit, from which point it was removed by other parties without cost to the Company. The small charge for team hoisting is due to the use of the Company's team at cost of feed.

Concrete.—Before beginning to place concrete, special provision was made for taking care of the surface water. Over the pit bottom was laid a series of open-joint, tile drains leading to a sump and controlled by a gate at the sump. A 5-in. centrifugal pump, belt-connected to a 20-h. p. motor owned by the Company, was installed to handle this water. The bottom of the pit was then covered with 6 in. of gravel, giving the water free access to the drains, and over this was spread cement sacking. Upon the bottom thus prepared was placed the concrete.

Concrete, for the pit bottom and walls, and for the belt shafts to a point above the ground-water level, 10 ft. below the surface, was mixed in the proportion of 1 part of Portland cement, 2 parts of sand and 4 parts of river gravel. Above this depth, and for all other structures, the proportions were 1:3:5.

The cement used was an American Portland brand, costing $2.25 per bbl. in San Francisco and $3.26 per bbl. laid down on the work. Sand of good quality was secured from a slough ¾ mile distant, at a cost of 41.7 cents per cu. yd. River gravel was procured from bars in the Tule River, from 1½ to 2½ miles distant.

These bars contained from 80% to 85% of sand and from 15% to 20% of gravel, thus necessitating screening. The nearest bar yielded 315 cu. yd., at a cost of $1.42 per cu. yd., and the upper bar, 126 cu. yd., at a cost of $2.70 per cu. yd.

The concrete was mixed by hand, on a platform at the edge of the pit, in batches of approximately ½ cu. yd., and lowered into the pit by horse hoist. In general, the gang consisted of seven men on the ground, two preparing the batches and five mixing, watering, filling hoist boxes and operating the hoist. Three or four men worked in the pit, placing, tamping and finishing.

In mixing, the gravel was first laid down and leveled off in a 3-in. layer. The sand was then placed on this and leveled off, and a layer of cement was placed on top. Each batch was then mixed twice dry and twice wet, water being supplied from a hose. The concrete was mixed quite wet, so as to flush readily under the tamping iron.

No forms were necessary in placing the bottom concrete. For the pit walls, oval ribs of 2 by 12-in. timber were built up of such dimensions as to allow 1-in. boards or lagging, placed vertically against the outer edge of the rib, to bring the ribs to the true section of the finished concrete. These ribs were spaced 2 ft. apart, vertically, and 1 by 6 by 24-in. lagging was used in forming the staves.

The plans called for ⅞-in. steel bars in the bottom concrete, with a spacing of from 4.7 to 9 in. These bars could not be obtained in the California market in less than 90 days, and, in order to avoid this delay, ¼ by 2-in. "medium" steel bars were substituted, thus using 50% more steel than called for.

All interior surfaces of the pit and shafts were covered with a cement-plaster finish, in the proportion of one part of Portland cement to 1½ parts of sand, and troweled to a smooth finish.

The writer has now to record one of the most disagreeable features of the work. Tests of the Portland cement, for fineness, soundness and tensile strength, were made before placing the order for the lot required in this work. No chemical analysis was made. The tests were conducted under the rules of the American Society of Civil Engineers, and showed great uniformity in grinding, no checking or blowing and a tensile strength somewhat greater than the average. In fineness, the average of six samples passing the 10 000-mesh sieve was 96.9 per cent. In tensile strength, the average of six samples of neat cement at two days was 447 lb.; seven days, 692 lb.; and 28 days, 899 lb. Initial set took place in from 1 hr. 45 min. to 2 hr., and final set in 5 hr. 30 min. No tests for fineness or tensile strength were possible at Porterville, but, on receipt of the cement, samples were taken from 10-bbl. lots, and pats were made which were observed for set and soundness. No defects in the cement were to be observed through the action of these pats, at the time of making or at any subsequent time.

The cement was received at the work in one lot of 1 800 sacks (450 bbl.), and within one week was being used in the pit concrete. Its action in the concrete was good, initial and final set taking place as usual, its entire behavior being apparently normal.

About 8 weeks after the concrete was placed it began to disintegrate, breaking down completely into its original constituents, with no cohesion whatever to be observed anywhere within the mass. This action did not take place throughout the entire body of concrete, but was confined to the pit bottom and lower portion of the walls below the ground-water line, or about 16 ft. above the bottom of the pit, and occurred here only in pockets, other portions remaining perfectly sound. The pit and belt shafts contained 118 cu. yd. of concrete, and, of this, 28 cu. yd. had to be replaced on account of this disintegration.

The cause of this disintegration is believed to have been due to the cement being insufficiently burned and possibly insufficiently ground, and also to excess of lime. It has been learned that the superintendent of the cement works, who is said to be thoroughly proficient, was unavoidably absent from the works for some two weeks, and that at least a portion of the cement for the Porterville shipment was turned out during that time.

TABLE 3.—COST OF CONCRETE FOR PIT AND BELT SHAFT.

Items.	Quantities.	Rate.	Total amount.	Cost per cubic yard. (146 cu. yd.)	
LABOR:					
Mixing and lowering	508¼ hr.	20 cents.	$101.65	$0.7966	$1.7897
Team lowering	293 "	5 "	14.65		
Placing	67 "	30 "	20.10	0.4295	
"	213 "	20 "	42.60		
Tamping	102 "	30 "	30.60	0.4835	
"	200 "	20 "	40.00		
Laying steel	20 "	30 "	6.00	0.0801	
" "	28½ "	20 "	5.70		
FORMS:					
Carpenter	116 "	37½ "	43.50	0.7464	0.7464
"	96½ "	30 "	28.95		
" helpers	182½ "	20 "	36.50		
MISCELLANEOUS:					
Labor	194¼ "	....	47.42	0.3247	1.2474
Sump pump	119¾ "	....	26.73	0.1830	
Foreman	....	....	108.00	0.7397	
Cost of labor			$552.40	$3.7835	$3.7835
MATERIALS:					
Sand	....	....	$25.14	$0.1722	$7.2257
Gravel	....	....	269.80	1.8479	
Cement	678 sacks.	81.6 cents	553.25	3.7893	
Steel	2 440 lb.	....	113.95	0.7804	
Tools and blacksmithing	....	....	39.42	0.2700	
Lumber for forms	2 155 ft.	....	53.42	0.3659	
Cost of materials			$1 054.98	$7.2257	$7.2257
Cost of labor			552.40	....	3.7835
Total cost of concrete			$1 607.38	....	$11.009

The cost of the concrete for the pit and the belt shaft is given in Table 3.

The breaking down of the concrete, due to defective cement, was not only expensive on account of the increased yardage, but was disastrous in affecting the cost of the plaster finish. During the time elapsing between the first finish of the work and its replacement, the surface-water drainage behind the pit lagging had become clogged, causing a static pressure against the concrete, according to its depth below the ground-water line. The concrete was found to be pervious, as all concrete is, and the percolation through the new concrete destroyed the new plaster coat, wherever placed, before it had time to set. Weep-holes through the work proved to be of no value, and each section broken by the replacement of the concrete was taken in hand separately.

Beginning about the circumference of such a section, the plaster was placed over a small area, and the blue flame of an ordinary plumber's gasolene torch was blown directly on the finish. The green finish set at once, adhering well to the concrete behind it. In this way the weeping area was gradually reduced, and, when brought to somewhat less than 18 in. in diameter, a plank form, shaped to the walls and surrounded by a rubber ring gasket, the interior being filled with cement plaster, was placed against the weeping area and held tight by a screw-jack until the enclosed plaster had well set. This method was expensive, as plaster finish goes, but was very effective, the total seepage through the pit walls, bottom, and belt shafts, being only 12 gal.* per hr. on the completion of the work, and most of this was due to the water following along the ladder irons in the pit wall. The first cost of the plaster finish amounted to $3.07 per square (100 sq. ft.) for labor and $3.98 for materials; total, $7.05 per square. The repair cost, in the aggregate, $145.45.

Engine-House.—The engine-house consists of framing covered with corrugated galvanized iron, the dimensions and details being shown on Plate I. The superstructure rests on concrete foundations. The floor and engine foundations are of concrete covered with a smooth cement-plaster finish. Gutters, built in the concrete floor, carry all engine piping. The cost of the completed structure was as follows:

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* This was handled by a hydraulic ejector or jet pump, operating on service pressure, at practically no expense.

Concrete, 41 cu. yd. at $7.1229		$289.56
Plaster finish, including floating of engines		44.22
Superstructure, Labor	$140.35	
Materials	322.92	463.27
Total cost of engine-house		$797.05

Pumping Machinery.—The pumping machinery consists of two 32-h. p. gas engines, belt-connected to two 9 by 12-in. triplex, single-acting, power pumps. These two engines are operated at the same time only in case of fire.

Engines.—The engines are of the four-cycle type, with water-cooled cylinders and fly-wheel governors. Their normal speed is 200 rev. per min., which is capable of hand regulation to 40% below or 10% above normal. Ignition is effected either by a sparking dynamo, belt-connected to the engine shaft; by a 12-cell sal-ammoniac carbon-zinc battery; or by a hot tube, as may be advisable.

Cooling water is taken from the city mains, and, after leaving the engine cylinder, is discharged by gravity into an irrigating ditch at the back of the engine-house. The engines operate either on gasolene, distillate, or on Coalinga crude oil, although the intention was to operate them wholly on the crude oil. The engine is fitted with two suction pumps, one for gasolene or distillate, and the other for crude oil. By these pumps the fuel is drawn to the engine and then by force pump carried into the cup at the receiving valve port. In operating, the engine is started on gasolene or distillate, upon which it may be run entirely. If crude oil is to be used, the exhaust from the engine is deflected, by a damper, through a converter. After this converter has become thoroughly heated, the crude oil is admitted, vaporized and carried to the engine as a gas, the change from gasolene or distillate to crude oil being made gradually by closing off the supply of the former and admitting the latter. Any surplus fuel drawn to the engine by the pumps is returned to the supply tanks by gravity lines. From time to time, the residuum from the crude oil or distillate passed through the converter is drawn off, while hot, from a collecting reservoir at the bottom of the converter.

These engines are operated with all grades of gasolene and distillate above those of 45° gravity, taking the charge cold. The converter is used when those of lower gravity are used.

The engines are connected to the pumps by 7-in., eight-ply, double-stitched, rubber belting. No loose pulley is used, the load, in starting, being thrown off by by-passes on the pumps. Belt tighteners, throwing in and out by hand-gear, are provided for use, if necessary, at maximum load.

The engines were contracted for at a price, f. o. b., Porterville, the contract also providing for hauling them to the plant, setting them on the foundations and connecting the piping.

Pumps.—The pumps are 9 by 12-in. triplex, single-acting, with outside-packed plungers and machine-cut gears. Each has a capacity of 500 gal. per min. at a pressure of 100 lb. per sq. in. They were made by the Dean Steam Pump Company, of Holyoke, Mass. The gearing is in the ratio of 8 to 1. Each pump is by-passed by connecting the suction, immediately in front of the pump, to the discharge, by a 4-in. vertical riser and an angle valve, a 10-in. check-valve being inserted in the main between the engine-house and the elevated tank to prevent back pressure when the by-passes are open.

The pumps were contracted for at a price, f. o. b., Porterville, the contract also providing for hauling them to the pit and setting them on the foundation bolts in the bottom of the pit.

Table 4 gives the cost of the pumping machinery, erected and complete.

Oil Tank and Setting Gasolene Tanks.—The oil tank, as designed, consists of an 8-in. circular shell of concrete, 12 ft. inside diameter,and with 4 in. of concrete on the bottom, the whole being finished inside with cement plaster in the proportion of 1 part of cement to 1½ parts of sand. The roof, of galvanized, corrugated iron over 1-in. sheeting, rests upon stringers set in the concrete. The tank is set 8 ft. in the ground, and suction, feed and gravity return pipes are carried to the engines. A 4-in. inlet pipe is provided for filling, and there is a 1½-in. hand sump pump to draw off accumulating water. In excavating, the material encountered was a heavy adobe. The cost of the structure is given in Table 5.

TABLE 4.—Cost of Pumping Machinery, Erected, Complete.

ENGINES.			
Two 32-h. p. engines (contract price)		$2 860.00	
Haul, placing on foundations and connecting piping (contract price)		90.00	
Belt tighteners, two	$76.25		
" " framing and placing	22.55		
		98.80	
Fittings, foundation bolts, tubes, etc		47.59	
Labor, lining up, adjusting, etc., 124 hr. at 30 cents		37.35	
Belting		141.48	
Miscellaneous materials		10.79	
Total cost of engines			$3 286.01
PUMPS AND PUMP PIT FITTINGS.			
Two 9 by 12-in. single-acting triplex pumps (contract price)		$2 816.00	
Haul and placing on foundations		170.00	
Foundation bolts, tubes and setting same		41.65	
Special castings		372.12	
Pipe, flanges and bolts		248.01	
Valves		160.68	
Fittings, gaskets, miscellaneous and blacksmithing		133.97	
Labor, connecting up		99.60	
Ejector, pipe fittings and connecting up		38.30	
Cost of pumps and pump pit fittings			$4 080.33
Total cost of pumping plant			$7 366.34

TABLE 5.—COST OF OIL TANK, ETC.

Item	Rate	Amount
Excavating, pick and shovel, 44 cu. yd.	at $0.5588	$54.59
Concrete, 13 cu. yd.	" 9.3248	121.12
Plaster finish, 6.3 squares	" 3.0064	18.94
Roofing		51.96
Sump pump and fittings		5.18
Setting two 65-gal. gasolene tanks		13.20
		$234.99

Two weeks after the concrete was placed, the plaster finish was put on, the concrete appearing wholly normal. Fifteen days after plastering and thirty days after concreting, a carload, 6 500 gal., of crude Coalinga oil was received, and, after a thorough examination of the tank, when everything was found to be apparently in good condition, this oil was run in. The oil was transferred from the car to the tank by a small tank wagon, holding from 300 to 350 gal., and was run into the tank through a 1½-in. rubber hose. Before the oil was of sufficient depth to form a cushion, it fell directly on the concrete bottom, about 9 ft. below the inlet. Owing to the small capacity of the wagon and interference caused by construction work about the plant, it was a little more than two days before all the oil was transferred to the tank.

No evidence of seepage through the tank or of anything abnormal was noticed during this time. During the evening of the day on which the last oil had been run into the tank, the city water began to taste of oil. This was attributed to the lubricating oil used in the stuffing-box of the centrifugal pump having worked down into the pump, as this had frequently occurred before.

On the following morning the city water was undrinkable, and pure oil ran from the taps when first opened. Examination of the plant showed that the ground-water contained oil, which entered the cased well below the concrete bottom of the pit in which the city pump operated. The oil in the tank was at once transferred to barrels, and the water from the city pump was cut off from the mains and wasted in an adjoining ditch, while a temporary supply for the town was obtained by tapping a canal from the Tule River which passed near the storage tanks east of the town. This gave a pressure of about 15 lb. per sq. in.

The oil tank, upon being emptied, showed nothing abnormal except under the spot where the oil was run in, and there, where the oil stream fell on the bottom, the plaster finish, covering an area about 1 ft. in diameter, had disappeared. This erosion must have taken place when the first oil had been run into the tank, and before sufficient depth had been obtained to cushion the falling stream. It was attributed to the defective cement to which reference has been made. Although this eroded area unquestionably added materially to the rate of seepage through the tank walls and bottom, this seepage took place over the entire wetted area, as was proved by excavating along the outside of the tank concrete.

That the lost oil through the tank did not appear sooner is probably due to the impervious character of the adobe soil in which the tank was built, the oil requiring some time to work its way through this soil into the gravel stratum carrying the ground-water.

Concrete tanks, for the storage of fuel oils having a gravity ranging from 15° to 20° on the Beaumé scale (0.967 to 0.936 specific gravity), are frequently and successfully used. In this instance the gravity of the oil is variously stated at from 30° to 35° Beaumé (corresponding to from 0.880 to 0.850 specific gravity). Where may the dividing line between success and failure be placed?

In making repairs, a riveted-steel tank, with soldered seams, was built up of No. 20 steel. It was 1 in. less in diameter than the inside diameter of the concrete tank. This steel tank was then lowered within the concrete shell upon a bottom of grout prepared for it, and, after being filled with water to prevent it from floating, the ½-in. space between the two tanks was filled with grout.

The total seepage loss of oil through the concrete tank was 2 133 gal. and the total cost of the direct repairs was $264.50.

Reservoir.—The details of the reservoir are shown in Fig. 2. Owing to the small size and to the shape of the excavation, *i. e.*, circular and 52 ft. in diameter, the plow and slip scraper could be used only to a slight extent and to but little advantage. The excava-

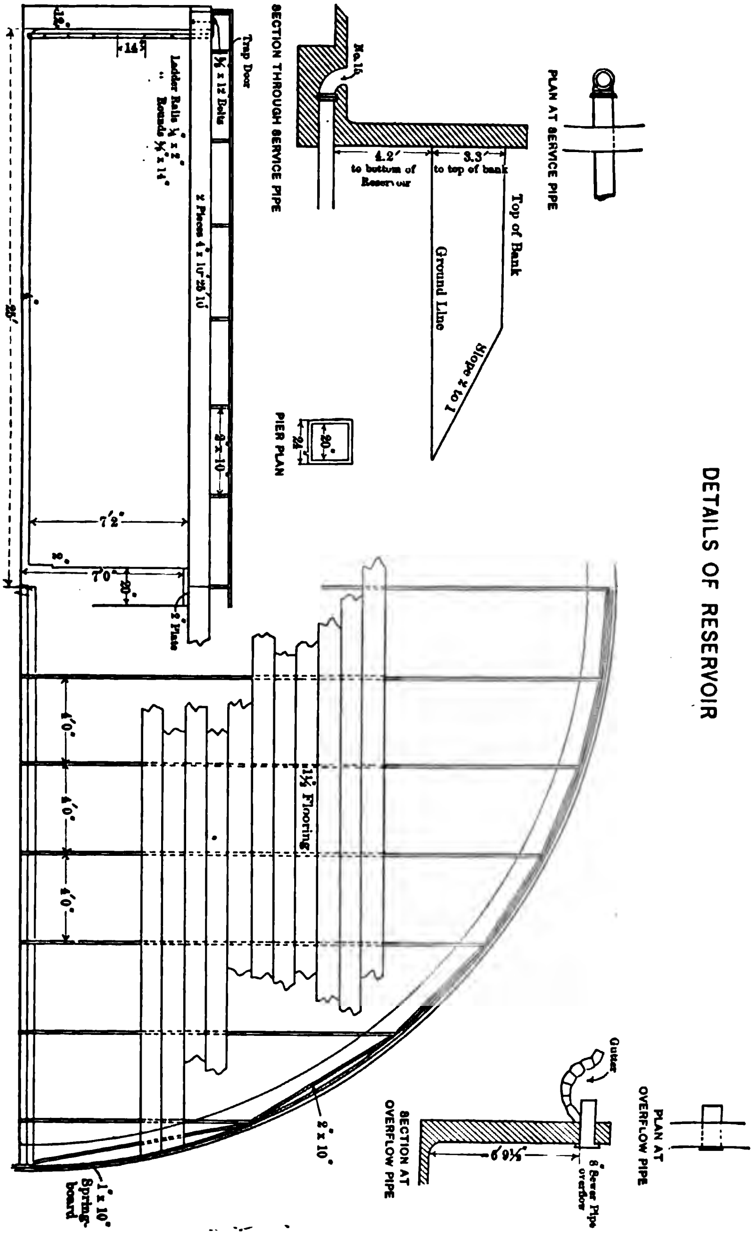

DETAILS OF RESERVOIR
PLAN AT SERVICE PIPE
No.15
4.2' to bottom of Reservoir
3.3' to top of bank
Top of Bank
Ground Line
Slope 2 to 1
SECTION THROUGH SERVICE PIPE
20"
24"
PIER PLAN
Trap Door
¾" x 12 Bolts
Ladder Rails ¾" x 2"
" Rounds ¾" x 14"
2 Pieces 4 x 10" 25' 10"
2 x 10
14"
12"
25'
7'2"
7'0"
20"
8"
2 Plate
4'0"
4'0"
4'0"
1½ Flooring
2 x 10"
1" x 10" Spring-board
HALF SECTION
HALF PLAN
PLAN AT OVERFLOW PIPE
SECTION AT OVERFLOW PIPE
Gutter
8" Sewer Pipe overflow
6'9½"

FIG. 2.

tion was principally pick and shovel work, and the material encountered was a heavy adobe. The excavation was carried to a depth of 4.2 ft. and banked up around the outside, forming a berm with a 4-ft. crest and with slopes of 2 to 1 on the outside. This berm and the natural soil were afterward trimmed vertical on the reservoir side, the trimmed surface forming the outside of the concrete wall. The bottom was also carefully trimmed to a close grade.

For forms for the circular wall, triangles of 2 by 4-in. and 2 by 6-in. scantlings were made, the 2 by 6-in. piece being 8 ft. long and placed vertically, one 2 by 4-in. piece at right angles and extending on the ground toward the center of the reservoir, while the second was used as a tie-brace. They were held in place by wooden pins driven into the bottom. Against the faces of these triangles were sprung 1 by 12-in. by 16-ft. planks, the concrete being deposited between these planks and the trimmed earth. Four triangles were used for each 16-ft. section of wall. The method of mixing and the proportions of the concrete used have been already described.

The roof was flat, and was of 1 by 12-in. undressed lumber on joists 4 ft. apart, between centers. The joists were supported by a diametrical girder resting on a central pier and the reservoir walls. The cost of the structure is given in Table 6.

TABLE 6.—COST OF RESERVOIR.

Excavation......	330.4 cu. yd.	at 0.586........	$191.08
Haul	300.3 "	" " 0.204........	53.98
Concrete	75 "	" " 8.338........	624.74
Plaster finish....	35.1 squares	" 2.918........	102.45
Roof...........	4 000 ft., B. M.	at 45.49	181.96
Trimming outer slopes........................			18.70
Total cost			$1 172.91

The cost of excavation includes loading 300.3 cu. yd. of material, and hauling it a distance of about ¾ mile. The cost of this loading, hauling and disposal amounted to $53.98, and it was sold for $107.71, FOUNDATION FOR TOWER AND TANK AT PORTERVILLE, CALIFORNIA

CAPACITY 75 000 GAL.

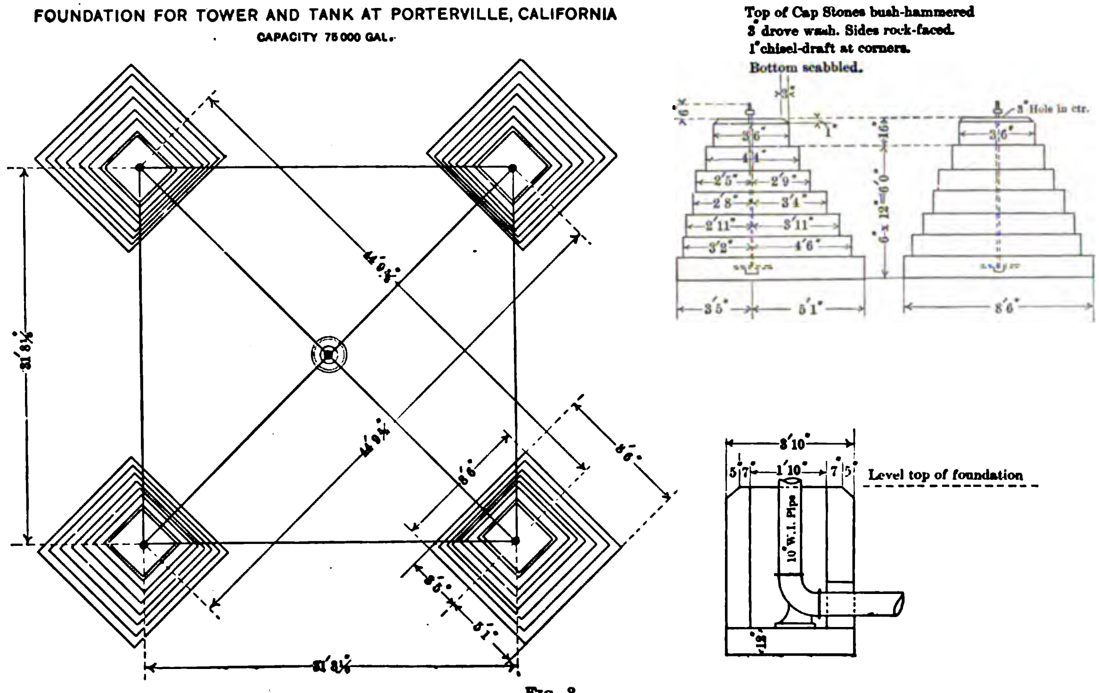


FIG. 8.

leaving a profit of $53.73. For the concrete, the labor cost $3.026 and the material $5.312 per cu. yd.

In plaster finishing, no attempt was made to remove trowel marks. The labor charge for vertical surfaces was $1.116 per square; for horizontal surfaces, $0.574 per square; and the materials cost $1.859 per square, in each case. The roof labor cost $12.43 per 1 000 ft., B. M., and the material $33.06, of which lumber cost $29.635 per 1 000 ft., B. M.

Steel Tower and Tank.—As previously stated, the original intention was to erect a six-post steel tower and a tank having a capacity of 100 000 gal., but curtailment of funds caused the final selection of a 75 000-gal. tank. The contract for this tank was let to the Chicago Bridge and Iron Works, on their own plans and standard specifications, for furnishing the material and erecting it on foundations prepared by the Porterville Water Company. The company also furnished the riser and overflow pipe. Figs. 3 and 4 show the dimensions of the principal details, and Plate II is a photograph of the tower and tank. All steel was inspected, and also all shopwork, at a cost of 75 cents per ton.

The specifications provided that the structure be proportioned for the following loads:

1.—The weight of the structure;

2.—The weight of the water in the tank;

3.—A wind pressure of not less than 30 lb. per sq. ft. over one-half of the diametrical plane of the tank, and a uniform load of 200 lb. for each vertical foot of the tower; the wind forces being assumed as acting in any direction, and the members to be proportioned for that direction giving the maximum stresses.

The unit stresses for proportioning members are as follows:

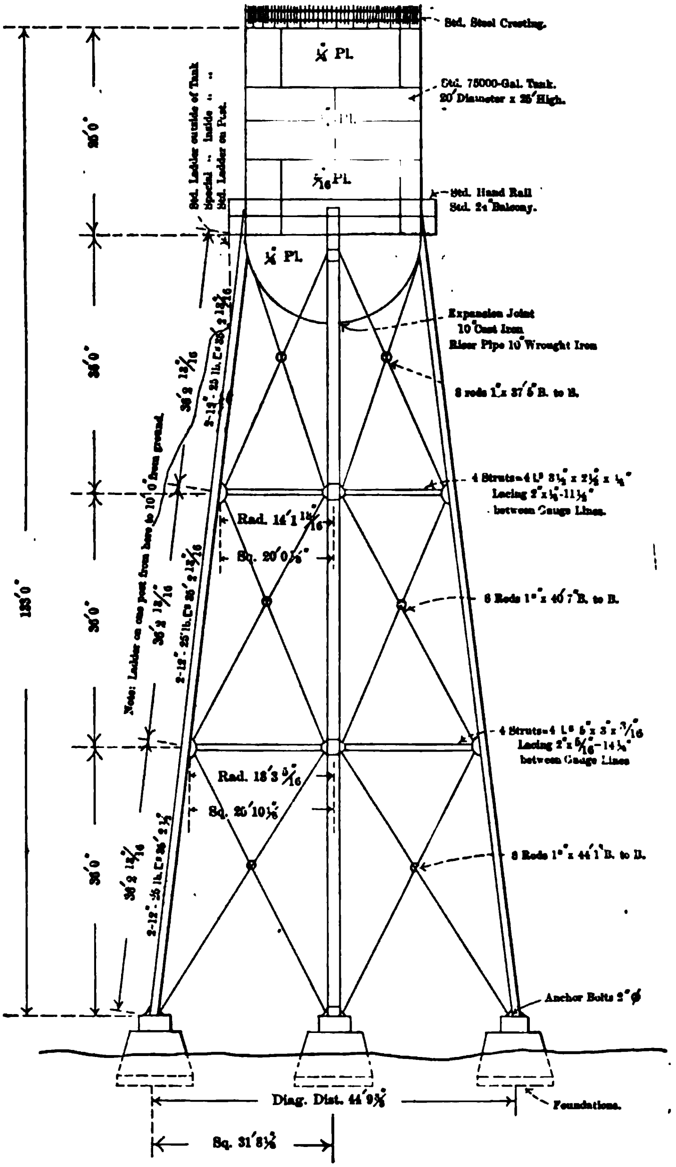
COMPRESSION:

For members not exceeding 90 radii of gyration between supports:

14 000 lb. per sq. in.

For length exceeding the above limit, use the following formula:

$$P = 20\,300 - 70\,\frac{L}{R}$$



TOWER AND TANK AT PORTERVILLE, CALIFORNIA.

CAPACITY 75 000 GAL.

FIG. 4.

P = Allowed stress per square inch;
L = Length between supports;
R = Least radius or gyration, in inches.

No mainpost to exceed 100 radii of gyration in length.

No other strut to exceed 150 radii of gyration, or such length that the fiber stress due to bending from its own weight exceeds 4 000 lb. per sq. in.

TENSION:

10 000 lb. per sq. in., net section.

SHEAR:

7 500 lb. per sq. in.

BEARING:

15 000 lb. per sq. in. on rivets; 20 000 lb. per sq. in. on pins; 400 lb. per sq. in. on capstones; and 125 lb. per sq. in. on masonry.

For wind stresses, the above unit stresses may be increased 25 per cent.

All metal in the structure was required to be soft steel. All steel comprising the tank plates and principal parts of the main posts was to be made by the open-hearth process; other steel was to be either open-hearth or Bessemer.

Rivet steel was to show an ultimate strength of from 48 000 to 58 000 lb. per sq. in.; an elastic limit not less than one-half the ultimate strength; an elongation of 26%; and a bending test of 180° flat, upon itself, without fracture on the outside of the bent portion. The soft steel was to be the same as the rivet steel, except that the ultimate strength was to be from 52 000 to 62 000 lb. per sq. in. and the elongation 25 per cent.

In open-hearth steel made by the acid process, the phosphorous limit was to be 0.08%; in that made by the basic process, 0.04 per cent. All material received one shop coat of graphite paint, and was given a second coat after erection.

The tank is provided with a wooden roof of dressed redwood on joists, the latter resting upon the reinforcing angles so placed as to bring the top of the roof flush with the upper edge of the tank. The roof is provided with a scuttle hole over a ladder extending to the bottom of the tank on the inside. A 5-in. overflow pipe passes through the top plate immediately below the upper reinforcing angle. Outside of the tank, it was reduced to 3 in.

The riser pipe is 10-in., standard, flanged screw-pipe, and the gaskets are of ⅛-in. lead.

The foundation bolts are round, 2 in. in diameter and 7 ft. 4 in. long. The capstones are of granite, 3 ft. 6 in. square and 16 in. high.

The foundations are of concrete, in the proportions of 1 part of cement, 3 parts of sand and 5 parts of gravel. Each block is battered, so that the line of thrust passes through the center of gravity of each element. In excavating for the foundations, the character of the soil was such as to necessitate going much deeper than contemplated. Consequently, the yardage of the excavation and of the concrete were greatly increased. The excavated material from the pits, except that used for back-filling, was loaded into wagons, hauled ¾ mile and deposited, at a cost of 20.4 cents per cu. yd. It was sold at a clear profit of $15.30.

TABLE 7.—COST OF CONCRETE IN TANK FOUNDATIONS.

Segregation.	Quantities.	Rate.	Total amount.	Cost per cubic yard. (104.7 cu. yd.)	
LABOR:					
Wheeling sand and gravel	234½ hr.	20 cents.	$46.90	$0.4479	$1.2740
Mixing	190½ "	20 "	38.10	0.3638	
Placing	123 "	20 "	24.60	0.2349	
Tamping	119 "	20 "	23.80	0.2274	
FORMS:					
Carpenter	64 "	30 "	19.20	0.1835	0.1835
Miscellaneous and foreman			44.48	0.4248	0.4248
			$197.08	$1.8823	$1.8823
MATERIALS:					
Sand			14.18	$0.1354	$5.8592
Cement	387 sacks.	81.6 cents.	315.79	3.0101	
Gravel			276.96	2.6452	
Form lumber (old)					
Tools			7.19	0.0685	
Cost of materials			$614.12	$5.8592	$5.8592
Labor and forms			197.08	1.8823	1.8823
Total cost of concrete			$811.20	$7.7415	$7.7415

The concrete in the tank foundations was placed at less cost than that in any other part of the work, except in the engine-house. Its distributed cost is given in Table 7, in comparison with the distributed cost of the pit concrete. It will be observed that the cost of gravel in this case was $2.70, while that in the pit concrete was only $1.42 per cu. yd.

The cost of the completed structure is given in Table 8.

TABLE 8.—Complete Cost of Elevated Tank.

Excavation (pick and shovel), 156.9 cu. yd.	at $0.6484 ...	$101.74
" back-fill .... 52.2 " "	" 0.1226 ...	6.40
" loading, hauling and delivering 104.7 cu. yd., excavated material ¾ mile distant	" 0.204 ...	21.35
Concrete, 104.7 cu. yd....................	" 7.7415 ...	810.53
Capstones, 65 cu. ft. in place.............		231.55
Tower and tank, 78 532 lb. steel, erected....	" 0.06597...	5 191.00
" " " riser pipe, 10-in. standard screw-pipe, 102 ft. 2 in................................		269.23
Tower and tank overflow and miscellaneous..............		19.51
Total cost of entire structure..........................		$6 650.81

Tank Ratios.—It is interesting to compare the ratios between the weights of the tanks, of the tower, and of each entire structure, with the weight of the water in each tank, and observe the economy in material in proportion to the capacity. These ratios, also, may be of value for preliminary estimates of the weights of tanks and towers, and consequently their cost, where the heights and capacities approximate those given and where the loading and unit stresses are the same.

Cast-Iron Pipe, Services and Connections.—The streets of Porterville are not paved, but have been crowned, covered with from 2 to 4 in. of mixed clay and gravel, and rolled hard. In trenching for the pipe, a 4-horse subsoil plow was used to break through this crust. The material below was a heavy adobe, except for 900 ft. of

4-in., 300 ft. of 6-in. and 600 ft. of 8-in. pipe, where sand was encountered. The width of the trenches was 18 in. in all cases, and the average depth 3 ft. 4 in. In back-filling, a "go devil" was used wherever practicable to throw the material into the trench, where it was consolidated by water from the street hydrants.

TABLE 9.—WEIGHTS AND RATIOS.

100 000-gal. tank, 22 by 28 ft. Spherical bottom. Height of tower, 95 ft. Height above foundations, 133 ft.

Weight of tank	39 600	lb.
" " tower	49 773	"
Total	89 373	"
Ratio: weight of tank to weight of water	1: 21.04	
" " " tower " " " "	1: 16.74	
" " " entire structure to weight of water	1: 9.32	

75 000-gal. tank, 20 by 25 ft. Spherical bottom. Height of tower, 98 ft. Height above foundations, 133 ft.

Weight of tank	34 260	lb.
" " tower	44 272	"
Total	78 532	"
Ratio: weight of tank to weight of water	1: 18.20	
" " " tower " " " "	1: 14.12	
" " " entire structure to weight of water	1: 7.96	

The fire-hydrants are of the Greenburg type, San Francisco standard. They are provided with two 2½-in. outlets and are fitted for 4-in. and 6-in. connections to street mains. After setting, they were well backed with boulders about their bases.

Valve boxes are placed over all valves, short pieces of cast-iron pipe, placed bell down, being used. All service connections are ¾-in. Corporation cocks and flange couplings are of brass, taper-threaded, of the Mueller lead-flange type, with extra heavy, lead-pipe, gooseneck. The wages paid on this pipe work were as follows: foreman $4.00, caulkers $2.50, yarners $2.25, and laborers $2.00 per day of 10 hours. The distributed cost of this work is given in Tables 10 to 15, and Table 16 gives a summary of the cost of the complete plant.

TABLE 10.—Cost of Laying 4-inch Pipe.

Laying length of pipe	2 820 ft.
" " " specials	26 "
Total laying length	2 846 "

Segregation.	Quantities.	Rate	Total amount.	Cost per foot.	
Labor.					
Trenching	991 hr.	20 cents	$198.20	$0.0696	
" team	16 "	5 "	0.80	0.0004	
Bell-holes	220½ "	20 "	44.10	0.0154	
Laying	187 "	20 "	27.40	0.0096	
Yarning	68 "	22½ "	15.19	0.0054	
Pouring	54 "	20 "	10.80	0.0038	
Caulking	87 "	25 "	21.75	0.0076	
Back-filling	160½ "	20 "	32.10	0.0113	
" team	76 "	5 "	3.80	0.0014	
Distribution	22.443 tons.	60 "	13.47	0.0047	
Miscellaneous	56	....	12.89	0.0040	
Foreman	....	....	47.52	0.0166	
Timekeeper	....	....	6.27	0.0022	
Cost of labor			$434 29	$0.1529	$0.1529
Materials.					
Pipe, 2 820 ft	32 150 lb.	$44.40 per ton.	$1 312.50	$0.4612	
Specials	4 462 "	0.03¼ per lb.	145.01	0.0509	
Valves	9	9.40 each.	84.60	0.0297	
Hydrants	5	28.60 "	143.00	0.0502	
Lead	2 010 lb.	0.05328 per lb.	107.09	0.0376	
Yarn	105 "	0.0541 "	5.68	0.0020	
Tools	....	....	42.49	0.0149	
Miscellaneous	....	....	26.19	0.0092	
Cost of materials			$1 866.56	$0.6557	$0.6557
Cost of labor			434.29	0.1529	0.1529
Total cost			$2 300.85		$0.8086

TABLE 11.—Cost of Laying 6-inch Pipe.

Laying length of pipe	816 ft.
" " " specials	22 ft.
Total laying length	838 ft.

Segregation.	Quantities.	Rate.	Total amount.	Cost per foot.	
Labor.					
Trenching	315¼ hr.	20 cents.	$63.10	$0.0753	
" team	5 "	5 "	0.25	0.0003	
Bell-holes	70 "	20 "	14.00	0.0169	
Laying	56 "	20 "	11.20	0.0133	
Yarning	19 "	22½ "	4.27	0.0051	
Pouring	27 "	20 "	5.40	0.0064	
Caulking	33 "	25 "	8.25	0.0098	
Back-filling	51 "	20 "	10.20	0.0122	
" team	24 "	5 "	1.20	0.0014	
Miscellaneous	18 "		4.07	0.0049	
Distribution	17.194 tons.	60 "	10.32	0.0123	
Foreman			15.12	0.0180	
Timekeeper			2.00	0.0024	
Cost of labor			$149.88	$0.1788	$0.1788
Materials.					
Pipe, 816 ft	26 244 lb.	$43.40 per ton.	$569.49	$0.6788	
Specials	1 420 lb.	0.03¼ per lb.	46.14	0.0550	
Valves	10	15.65 each.	156.50	0 1866	
Hydrants	9	29.85 "	268.65	0.3203	
Lead	804 lb.	0.06003 per lb.	48.27	0.0516	
Yarn	42 lb.	0.0541 "	2.27	0.0027	
Tools			13.52	0.0161	
General			8.33	0.0099	
Cost of materials			$1 108.17	$1.3210	$1.3210
Cost of labor			149.88	0.1788	0.1788
Total cost			$1 257.55		$1.4998

Operation.—At the time of writing, the plant has been in operation a little more than three months, and some notes on its performance may be of interest.

The population served by the plant is about 1 200, and the plant was designed on the basis of an average daily consumption of 125 gal. per capita,* which rate it was expected would be reached by ordinary restrictive measures, and inspection on the part of the management. This rate of consumption represents an average pumpage of 5 hr. per day, which would allow one man to attend to the plant while running and also do all the outside work, making taps, repairs, collections, etc., thus reducing the cost of attendance and superintendence to the salary of this one man.

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*The excessive consumption under the old system had been pointed out in the first reports, and attention called to the necessity for reducing it.

Table 17 covers the pumpage and cost of operation of the plant from March 22d, when it was turned over to the operating department, to June 30th.

TABLE 12.—COST OF LAYING 8-INCH PIPE.

Laying length of pipe	2 512 ft.
" " " specials	46 "
Total	2 558 ft.

Segregation.	Quantities.	Rate.	Total amount.	Cost per foot.	
LABOR:					
Trenching	901 hr.	20 cents	$180.20	$0.0706	
" team	15 "	5 "	0.75	0.0003	
Bell-holes	200½ "	20 "	40.10	0.0158	
Laying	202 "	20 "	40.40	0.0159	
Yarning	66 "	22½ "	14.85	0.0059	
Pouring	76 "	20 "	15.25	0.0061	
Caulking	129 "	25 "	31.75	0.0125	
Back-filling	146 "	20 "	29.20	0.0115	
" team	69 "	5 "	3.45	0.0013	
Miscellaneous	51 "		11.63	0.0037	
Distribution	65.862 tons	60 "	39.52	0.0155	
Foreman			43.20	0.0165	
Timekeeper			5.70	0.0022	
Cost of labor			$456.00	$0.1778	$0.1778
MATERIALS:					
Pipe, 2 512 ft.	115 225 lb.	$43.40 per ton	$2 500.39	$0.9774	
Specials	4 056 lb.	0.03¼ " lb.	131.88	0.0515	
Valves	5	24.00	120.00	0.0469	
Lead	3 618 lb.	0.05328 per lb.	194.72	0.0761	
Yarn	189 lb.	0.0541 " "	10.22	0.0039	
Tools			38.62	0.0151	
Miscellaneous			23.81	0.0093	
Cost of materials			$3 019.59	$1.1802	$1.1802
Cost of labor			456.00	0.1778	0.1778
Total cost			$3 475.59		$1.3580

TABLE 13.—Cost of Laying 10-In. Pipe.

Laying length of pipe	124 ft.
" " " specials	14 "
Total	138 "

Segregation.	Quantities.	Rate.	Total amount.	Cost per foot.	
LABOR:					
Trenching	120 hr.	20 cents	$24.00	$0.1738	
Bell-holes	10 "	20 "	2.00	0.0145	
Laying	15 "	20 "	3.00	0.0217	
Yarning	1½ "	20 "	0.30	0.0022	
Pouring	1½ "	20 "	0.30	0.0021	
Caulking	10 "	20 "	2.00	0.0145	
Back-filling	41 "	20 "	8.20	0.0595	
Miscellaneous	10¼ "	20 "	2.05	0.0148	
Distribution	4.533 tons	60 "	2.72	0.0197	
Foreman			2.16	0.0155	
Timekeeper			0.30	0.0021	
Cost of labor			$47.03	$0.3404	$0.3404
MATERIALS:					
Pipe, 124 ft	7 500 lb.	$43.40 per ton	$162.75	$1.1790	
Specials	608 "	0.03¼ per lb. and 0.04½ " "	24.59	0.1781	
Valves	1	34.60 each	34.60	0.2507	
Lead	268 lb.	0.05328 per lb.	14.42	0.1045	
Yarn	14 "	0.0541 " "	0.76	0.0054	
Tools			1.93	0.0148	
Miscellaneous			1.19	0.0086	
Cost of materials			$240.24	$1.7411	$1.7411
Cost of labor			47.03		0.3404
Total cost			$287.27		$2.0815

TABLE 14.—Cost of Making 78 ¾-inch Service Connections.

Segregation.	Quantities	Rate.	Total amount.	Cost per connection made.	
LABOR:					
Trenching	239 hr.	20 cents.	$47.80	$0.6128	
Tapping and making	195½ "	40 "	78.20	1.0026	
" " helper	112½ "	20 "	22.50	0.2885	
Back-filling	80½ "	20 "	16.10	0.2064	
Cost of labor			$164.60	$2.1103	$2.1103
MATERIALS:					
Goosenecks and cocks	78	2.48 each.	$193.64	$2.4800	
Fittings			31.01	0.4000	
Tools			68.33	0.8760	
Tapping machine			80.75	1.0353	
Cost of materials			$373.73	$4.7913	$4.7913
Cost of labor			164.60	....	2.1103
Total cost			$538.33	....	$6.9016

TABLE 15.—Cost of Making Connections Between Old and New Pipe Systems.

Six 2-in., three 3-in., and three 6-in. (lead).

Labor.	Hours.	General rate.	Total amount.
Trenching	153	20 cents.	$30.60
Making	30	40 "	12.00
" helpers	104	20 "	20.80
Back filling	45½	20 "	9.10
Miscellaneous	45½		13.65
Materials, fittings, etc			13.22
Total			$99.37

TABLE 16—Summary of Complete Cost of Construction.

	Dr.	Cr.
To well	$717.55	
" pump pit	2 588.80	
" engine-house	797.05	
" pumping machines	7 866.34	
" oil and gasoline tanks	499.59	
" reservoir	1 172.91	
" elevated steel tank	6 650.81	
" distribution system	7 958.96	
" wrecking city pump	24.84	
" maintenance, city pump, during construction	398.25	
" grading and improving grounds	48.14	
" general	2 851.98	
By cash received for sale of earth		$144.35
" " " " " " old form lumber, etc		73.29
" appraised value of stock on hand and tools		1 171.19
" balance: net cost of system		29 675.86
	$31 004.67	$31 064.67

The cost of pumping, in Table 17, is much less than the average for plants of this size, and compares very favorably with the cost in plants of a capacity many times as great.

The pumping record represents a probable pumpage of about 121 000 000 gal. per annum, or an average daily consumption of 280 gal. per capita. The minimum daily consumption occurred in March, and was at the rate of 150 gal. per capita; the maximum daily consumption (to date) occurred in June, and was at the rate of 465 gal. per capita. For such a town, with no manufacturing interests whatever, it is believed that these figures are without a parallel. This excessive consumption is due to several causes. The system is entirely unmetered, and some water is sold for the irrigation of lawns, etc., not in connection with domestic use, at a flat rate of 50 cents per month per lot of 50 ft. front. Prior to the installation of the new plant, the use of water by consumers was only limited by the capacity of the old plant. Since the new plant has been running, restrictive measures have been attempted, especially in the use of water for irrigation, and, while the consumption has been greatly reduced, the rate is still unprecedented. As an instance of the excessive use of water for irrigation, it may be stated that a meter was purchased by the Water Company and placed on the service pipe of a consumer using water for irrigation only. This consumer in eight days used 15 000 gal., or at the rate of 56 250 gal. per month. In the following month, after being informed that he would be required to pay for water as used, his entire consumption was only 6 150 gal.

Taking the cost of pumping at 13½ cents per million gallons per foot raised, and all other charges, interest, depreciation, etc., as 12 cents, the cost of the water supplied in this instance was $2.37, and the revenue, $0.50.

Fuel and Duty.—The calorific value of the fuel oils used in the plant is uncertain, but the writer believes it may be taken at an average of 19 600 B. t. u. for the crude Coalinga oil. This oil ranges between 30° and 35° on the Beaumé scale, which, at 32°, would give it a weight of 7.24 lb. per gal. At the time the plant was designed, it was proposed to use this fuel, which was then selling at 75 cents per barrel (42 gal.) at the wells. During the construction of the plant, the wells were acquired by the Standard Oil Company, and the price was immediately raised to $1.50 per barrel. At this rate, one car load was secured for the plant, after which the Standard Oil Company refused to sell any more at any price. This forced the Water Company to resort to the distillates or to install converters adapted to the heavier oils.

The distillate used is purchased in the open market from independent refineries, and is a by-product, as most of these refineries pass the crude oils through the stills to secure the asphaltum base. Nothing is known as to the calorific value of this distillate. Its gravity gives it a weight of 7.24 lb. per gal., as in the case of the Coalinga crude. It has been generally supposed that these low-gravity distillates had a heat value of from 5 to 10% in excess of the heavy crude oils, but in this case the engine performance shows that the distillate used has a calorific value of only 81.5% of the Coalinga crude oil, or 15 974 B. t. u.

TABLE 17.—PUMPAGE, FUEL CONSUMPTION, STATION EXPENSE, ETC., FROM MARCH 22D TO JUNE 30TH, 1904.

	Mch. 22–31.	April.	May.	June.
Total pumpage in gallons	1 660 000	7 887 500	12 678 001	13 831 080
" time pumped	55 hr. 20 m.	253 hr. 26 m.	458 hr. 6 m.	521 hr. 47 m.
Average consumption per tap (230) per day, in gallons	732	1 153	1 778	2 005
Average consumption per capita supplied per day, in gallons (consumers estimated at 1 200)	138	219	341	384
Average pressure on gauge, in pounds	50⅛	51⅛	52⅛	52¼
Average vacuum, in inches	11½	11⅛	11	10⅛
Dynamic head, in feet	160	162	164	163
Fuel consumption, in gallons:				
[a] Crude Coalinga oil	196	1 055	1 515	551
[b] Distillate, 55° gravity	112	106	70⅛	92
[c] " 32° "	....	....	....	1 393
Residuum, in gallons:				
From Coalinga	(?)	69	133	46
" 32° gravity, distillate	....	....	....	41
[d] Supplies:				
Engine oil, in gallons	11	13	22	30
" gasolene, in gallons	(?,	5	5	5
Pump oil, in gallons	9	16	25	27
" compounds, in pounds	....	5	8	7
Waste, in pounds	8	10⅛	19	16
Cost:				
Fuel	$19.22	$52.10	$66.37	$84.39
Supplies	10.88	18.40	28.89	33.51
[e] Attendance	32.26	107.50	130.12	180.00
Total station expense on above items	62.36	178.00	225.38	297.90
Cost per million gallons raised 1 ft. high, on above station expense	0.231	0.138	0.108	0.132

[a] Cost at wells, 3.57 cents per gallon. Freight and haul, 0.33 cent. Cost in tank 3.9 cents per gallon.

[b] Cost in tank, 10⅛ cents per gallon,

[c] Cost at refinery, 3.5 cents per gallon; freight and haul, ⅜ cent per gallon; cost in tank, 3.88 cents per gallon.

[d] Cost of engine and pump-lubricating oils, 50 cents per gallon; gasolene, 30 cents per gallon; waste, 11 cents per pound; gear compound, 25 cents per pound.

[e] Full time of Superintendent, at $100 per month, charged to station in March. In April, three-quarters time of Superintendent and full time of First Assistant, at $65 per month, for one-half month. In May, one-half time of Superintendent, full time of First Assistant, and seven days for Second Assistant, at $65 per month. In June, one-half time of Superintendent and full time for First and Second Assistants.

The writer believes that there is but little possibility of material error in this particular case, but, unfortunately, has been unable to make a personal test. The result is arrived at from the actual performance of the plant extending over the last fifteen days of June.

The 55° distillate is what is commonly called engine distillate, and is put on the market especially for use in engines of the gasolene type. Its calorific value is also unknown, but will not fall below that of the Coalinga crude, and will probably run a small percentage in excess. It is used in this plant simply to start the engines, being taken by them "cold." The engines are run on it until the generator has become sufficiently heated to handle the crude oil or heavy distillate.

Taking the performance of the plant through the month of May, the duty developed while operating on the crude Coalinga oil was 10 937 000 ft-lb. per gal. (7.24 lb.) of oil, or 1 510 600 ft-lb. per pound of oil. With bituminous coal at 12 740 heat units, this performance corresponds to a duty of 232 400 000 ft-lb. per 100 lb. of coal.

Taking the heat value of 32° distillate used, as previously indicated, the duty during the last fifteen days in June was, on the same basis, 8 918 000 ft-lb. per gal. (7.24 lb.) of distillate, or 1 232 000 ft-lb. per pound of distillate and 154 500 000 ft-lb. per 100 lb. of coal.

The best performance of the plant, extending over a period of several days, has been 1.43 pints of crude Coalinga oil per horse-power-hour. On the basis of 1 pint per horse-power-hour, brake test at the engine, this represents a combined efficiency of 70% for pump and belting, and the engines at ordinary performance are operating on 1.015 pints of crude Coalinga oil, or 1.146 pints of 32° distillate per horse-power-hour.

The increased cost of pumpage per million gallons per foot raised, from 10.8 cents in May to 13.2 cents in June, is due to the low value of the 32° distillate used.

The Coalinga crude oil is a very clean oil, there being but little accumulation in the generator or deposit in the engine cylinder. On the other hand, the 32° distillate is exceedingly dirty, leaving a gritty deposit within the cylinder, and requiring frequent cleaning and repacking of piston rings.

The writer has had difficulty in securing authentic data as to the fuel value of oils, and submits the following equivalents, obtained from various sources, believing that they may be of value to others.

Crude Bakersfield oil, 14 to 15½° gravity, contains, per pound, 19 388 B. t. u.

Crude Bakersfield oil, 14 to 15½° gravity, through refinery, per pound, 20 061 B. t. u.

Low-grade engine distillate, under 50° gravity, 18 000 B. t. u.

For use under steam boilers, the following equivalents may be used:

147.4 gal. crude oil equals 1 long ton, white-ash steam coal,
168 " " " " " " " Beaumont coal,
164 " " " " " " " Walls End coal,
193 " " " " " " " Welsh anthracite coal.

In general, for steaming purposes, 2 bbl. of ordinary heavy fuel oil may be taken as equal to 1 cord of good pine wood; and 3.6 bbl. of oil as equal to 1 ton (2 000 lb.) of bituminous coal.

The weights of oil will range from 7¼ to 7¾ lb. per gal. (42 gal. per bbl.).

Wooden Stave Pipe.—This pipe has been mentioned in reference to the old system, and that it was not wholly replaced with cast-iron pipe was due to lack of funds at the time. Since the new plant has been in operation, this pipe has caused much trouble. It is what is called 150-ft. pipe; that is, it is claimed by the makers to be designed for a static pressure of 150 ft., with a factor of safety of 4 at this pressure. The pipe is spiral-wound, in sections 12 ft. long, and in no part of the Porterville system is it subjected to a static pressure exceeding that for which it is claimed it is designed.

Some forty-one sections, or 492 ft., of this pipe have had to be taken out and replaced within the last three months. The trouble is caused by the variable pressure in the mains. This causes a gradually deeper seating of the winding into the wood, and results ultimately in the opening of the longitudinal seams between the staves. As the winding is spiral, there is no possibility of recinching, and the pipe is worthless.

In closing, the writer wishes to acknowledge his indebtedness to A. L. Adams, M. Am. Soc. C. E., for notes on the condition of the old plant, and to Mr. Charles Byers for his efficient services as Assistant during the latter half of the construction.

Vol. XXXI. JANUARY, 1905. No. 1.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
INSTITUTED 1852.

PAPERS AND DISCUSSIONS.

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TECHNICAL METHODS OF RIVER IMPROVEMENT AS DEVELOPED ON THE LOWER MISSOURI RIVER, BY THE GENERAL GOVERNMENT, FROM 1876 TO 1903.

By S. Waters Fox, M. Am. Soc. C. E.

To be Presented March 1st, 1905.

Introduction.

When the first work on the Missouri River was undertaken by the General Government, very little was known of the physics of the river; and the only existing information as to works adapted to its regulation was of a negative character, previous efforts having been almost exclusively confined, and without successful results, to bank protection with solid, impregnable dikes.

The successful improvement of the river by regulation demanded, first, an intimate knowledge of the characteristic features of the river—of all the elements the sums of which are expressed in the varying conditions of the flow that obtain during a full cycle

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Note.—These papers are issued before the date set for presentation and discussion. Correspondence is invited from those who cannot be present at the meeting, and may be sent by mail to the Secretary. Discussion, either oral or written, will be published in a subsequent number of *Proceedings*, and, when finally closed, the papers, with discussion in full, will be published in *Transactions*.

of changes; and secondly, that a system of efficient, permanent works at moderate cost should be devised for the rectification and fixation of channel flow.

Necessarily, methods of treatment progressed step by step, with close observation and study of conditions of the flow, as found in their natural state and as affected by the works; and, meanwhile, an expectant but ever-impatient public found occasion, in the numerous failures which attended the earlier experimental works, to express disapproval and lack of confidence, not only in the works, but more especially in the extensive surveys, gaugings, etc., which, from an engineering point of view, were of such vital importance.

Before attempting a description of the more important works, it is thought best to give a brief description of the river.

DESCRIPTION OF THE RIVER.

Formed by the confluence of three mountain streams—the Jefferson, Madison and Gallatin—the Missouri River, from its head (the mouth of the Gallatin), in latitude 45° 56′, longitude 110° 29′, to its mouth, in latitude 38° 49′, longitude 90° 7′, is 2 546.3 miles in length. It drains an area of 580 000 sq. miles, and its mean total annual discharge is estimated to be 20.15 cu. miles, or at a mean rate of 94 000 cu. ft. per second.

The head of navigation is at Fort Benton, 2 284.8 miles above the mouth.

Above Carroll—2 113.2 miles above the mouth—the river is characterized as the "Rocky River," because of the nature of the bed in which it flows.

Below Carroll it gradually assumes character, first as a sand-bearer, and farther on, through tributary flow and change in bed formation, as a silt and sand-bearer, until, at Sioux City, Ia., 807.4 miles above the mouth, it is a pronounced type of alluvial rivers.

From Sioux City to the mouth, with an average slope of 0.86 ft. per mile, and an extreme gauge oscillation of nearly 19 ft. at Sioux City, and of nearly 35 ft. from Kansas City to the mouth, the river finds its way, in a tortuous, divided, ever-shifting course, down a valley composed of a heterogeneous mass of northern drift and alluvium. The bluffs on either side, defining the main valley, constitute the only natural barriers to the lateral migrations of the stream; and, but for some occasional formations of indurated clays and low-lying boulders, the underlying bed-rock is the only natural barrier against depth to which, in engorged sections, the river will scour.

From a maximum width of 17 miles between bluffs, for a short stretch below Sioux City, the width of the main valley varies considerably; on the whole, however, it becomes narrower below as well as above. At Yankton, S. Dak., the valley is 3 miles wide, and at Fort Randall about ¾ mile; at Omaha its width is 5 miles, and at Kansas City about 2 miles; between Kansas City and Glasgow the valley is wider, reaching a maximum of 8 or 9 miles in the vicinity of Carrollton, Mo.; from Glasgow to St. Charles the width is more uniform, and averages a little more than 2 miles.

The bluffs in the upper valley are covered with grass, except on the steeper slopes, which are bare; lower down, they are covered with undergrowths and forest trees. They form the sides of a great rock trough, the bottom of which, underlying the alluvium which at present partially fills it, is found at depths of from 70 to 100 ft. below the general level of the main valley.

The surface of the lower valley, in its uncultivated state, is covered with vegetation, from the thicket of young willows and cottonwood, on the low-lying bars and tow-heads, to large forest trees and mixed undergrowths which are found on the islands and main banks. Large numbers of trees are precipitated into the stream by caving banks every year. When their roots become embedded in the sand they form snags, and menace river craft. Sometimes they become the nuclei of wrack-heaps, and obstruct the flow to such an extent as to cause radical changes in the channel.

Numerous borings, subaqueous foundation works and other data, show that the bed of the river is composed of gravel and sand in all degrees of fineness—from very coarse to highly comminuted—and clays. Large quantities of vegetable matter are also found, from the tiniest rootlets to the largest forest trees.

While, in general effect, there is a sorting out of these materials, the heavier being found near bed-rock and the lighter near the surface, there is no regularity of formation. The heavier materials are found at all elevations: in the shallow beds of high-water chutes, on the heads of bars, and even on the surface of high banks. The finer and lighter materials are found at great depths, as for instance, in old pools from which active flow has been suddenly diverted. Pockets, of greater or less area and thickness, at all depths and composed of any of the various materials, abound everywhere.

With such conditions of banks and bed, the difficulties of founding structures properly in the Missouri River must be apparent; and it will be understood why specifications should be drawn on broad lines and be of ready adaptability to local conditions.

Two floods occur every year with remarkable regularity—in April and June—and are known as the April and June floods, respectively. Both are destructive of property, and greatly disturb the channel.

The April flood is usually sharper than the June flood, and, when ponded back by ice, is very destructive, often producing the most astounding changes in channel alignment and location. The June flood, while usually higher, lasts longer, and, finding the channel in a measure prepared by the April flood, passes off with comparatively less damage to property and disturbance of channel.

For purpose of reference in establishing grades for river improvement works, bridges crossing the river, etc., the Missouri River Commission, in the fall of 1888, established two grade lines, from Sioux City to the mouth, respectively designated Standard High Water and Standard Low Water. The former was determined from the average of the highest known June floods to 1888; and the latter from the average of the lowest known stages to 1888 at which navigation was not prevented by ice.

The difference in elevation of the two planes at Sioux City is 10.42 ft., at Kansas City, 14.52 ft., at St. Charles, 16.13 ft.

Some idea of the effect of floods upon the regimen of flow may be formed from the fact that low-water discharge at a given stage—say standard low water—may vary as much as 100 per cent. It is approximately correct to state that standard low-water discharge at Sioux City may be anything from 15 000 to 30 000 cu. ft. per sec., and at St. Charles 20 000 to 40 000 cu. ft. per sec. To illustrate: at Sioux City the discharge in 1883 was nearly 70% larger than that of 1879 at the same stage; while in 1895 it was more than 50% smaller than that of 1879 at the same stage; or, to give stage and discharge, there was at Sioux City in 1883 a discharge of 32 000 cu. ft. per sec. at a stage 1.5 ft. below standard low water, and in 1895, at a stage 1.5 ft. higher, a discharge of only 15 100 cu. ft. per sec., and, in a general way, the same conditions prevailed throughout the river, to its mouth.

Such a change of plane, involving a doubling of volume of flow at a given stage, can only be accounted for on the theory that, by extensive bed movement during flood stage, the efficiency of the channel was commensurately increased. The flood conditions preceding the two sets of measurements mentioned bear out this theory. Those of 1883 followed closely upon a flood which, in the lower river, was a phenomenal one, while the effects of the great flood of 1881, from Sioux City down, must have been still marked in the channel and on the planes of both the 1882 and 1883 low waters; on the other hand, those of 1895 were taken at the close of a long period of low water and when, for the three preceding years, flood volumes had been deficient in a marked degree.*

At standard high water the discharge at Sioux City approximates 200 000, and at St. Charles 300 000 cu. ft. per sec.

The greatest measured discharge of the river was 650 000 cu. ft. per sec. at St. Charles, taken on the crest of the flood of 1892.

The maximum discharge of the great flood of May and June, 1903, exceeded that of 1892, being estimated at 750 000 cu. ft. per sec.

By the almost constant erosion of banks and bed, quantities of the composing materials are carried forward by the stream, in suspension and in a semi-fluid state close to the bottom. Even during midwinter, when the river may be frozen over from source to mouth and at extreme low stage, the water is never quite clear—never entirely free from sediment—while, in times of flood, immense quantities of sediment and drift-wood are borne along. It is estimated that every year the Missouri carries into the Mississippi enough sediment to cover a square mile 400 ft. deep. The character and quantity of the materials are such that if the current be checked a portion of it is dropped; and the rapidity and extent to which deposits are thus formed would seem incredible to one unfamiliar with the river. On the other hand, an increase in velocity means greater sediment-carrying capacity and therefore greater tendency to scour. These features are strikingly illustrated, in the unimproved river, by the gorge sections which result from sharp impingement of flow against bluffs, and the inevitable wide flat reaches with middle-bar growths below. They are also well shown by the deposits formed above and below permeable dikes within the zone of slackened currents, and the trenches or pot-holes near the outer ends of these structures where the velocity has been increased.

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* Report, Missouri River Commission, 1896, p. 3807.

As might be expected from such conditions, the course of the river is tortuous, and short reaches of sharply concentrated flow and great depth alternate with longer reaches of wide or divided flow and small depth. Innumerable bars, two-heads and islands, snags and wrack-heaps obstruct its flow. While the general slope of the river, from Sioux City to the mouth, is uniform, it is broken at the pools and crossings, being less than the average in the pools and greater on the crossings. During a full cycle of change, from low water to flood stage and return to low water, the place of entry of principal flow into a pool, under normal conditions, will move from near the head of the pool toward its foot, and back again to near its head. It is during these changes that the banks in the bend—on the concave sides of pools—cave most rapidly, and that the channel-ways in the crossings through the intervening bars are most unstable and troublesome to navigation. On the rising stages of a flood there is increase in pool depth due to scour, and there is usually a compensating fill back on subsidence of the flood. In the crossings, however, the increase in depth does not keep pace with the increase in stage of the river; and a rapid decline in stage often leaves the crossing with no well-defined channel.

IMPROVEMENT OF THE RIVER.

The improvement of the Missouri River for purposes of navigation, as undertaken by the General Government, contemplated its regulation by restriction of the flow to widths, at high and low water, which would give desired depths at all stages, on fixed alignment. The channel was to be kept free from obstructions, such as snags and wrack-heaps.

The restriction of width was to be accomplished:

First, by Rectification, with Permeable Dikes, through the agency of which—in their function as deposit builders—flow was to be concentrated, old chutes or channels being closed, new banks built up to desired height and alignment, and the desired improved channelway developed.

Second, by Fixation, with Bank Revetments, of Banks, whether natural or formed by rectification works, which conformed in position and alignment to the proposed banks of the improved river.

The history of the methods and devices used in the development of Missouri River improvement works embraces the period of twenty-seven years following 1876. It is full of interest to the engineer, contains much of original and scientific research, and has contributed in no small degree to the sum of present knowledge concerning the flow and proper treatment of detrital rivers. Its narration here cannot be attempted, but a brief outline is given, with a view of indicating the range covered by experimentation.

Permeable dikes.—The earliest permeable dikes on the Missouri River were composed of one or more rows of "Brownlow Weeds" in variously modified forms. In its simplest form the weed was composed of single pieces, or bundles, of brush trailing from a rope or cable, one end of the rope being anchored at the bottom and the other end supported at the water surface. The butt ends of the brush were attached to the rope at short intervals from bottom to surface, the other ends being free to trail down stream as impelled by the current. The length of the rope was from one and one-half to four times the depth, according to the exposure and the existing stage of the river. In a more elaborate construction, the weed resembled a series of umbrellas, formed by brush radiating densely from a central fascine, the latter being anchored at one end at the bottom, and supported at the other end on the surface of the water by a buoy.

The results obtained with weeds were instructive, but, on the whole, unsatisfactory, and, after a thorough trial, they were abandoned. Deposits covering large areas were quickly formed by them, but at elevations considerably lower than the highest stage to which the weeds were exposed, and most often they were not distributed uniformly, being broken by small waterways. Constant rotation or swirling often destroyed or detached the weeds; loss of, or leaking, buoys, a dragging down by drift-wood and finer vegetable growths, as well as by deposits, made others inoperative.

Buoyed curtains, or sectional gratings of brush or poles, anchored and buoyed in positions imbricating down stream, were also tried without success.

Later, extensive experiments were made with wire netting, of various forms and areas of mesh, and much ingenuity was displayed in its manufacture on the work by specially designed machines.

Dikes formed of a continuous piece of netting, anchored and buoyed in position, gave results which were little if any better than those obtained with weeds. Fixed supports were then substituted for buoys, with marked improvement, but developed the weak points of the netting. When held rigidly in the current, the netting was likely to be punctured and torn by large pieces of drift-wood, or, being strong enough to resist rupture, would bag down stream under the strain, thus inviting the accumulation of drift-wood which sooner or later destroyed it. But, what is of more importance, the trial of wire netting with fixed supports developed the necessity for provision against scour, many of the failures being due to that cause.

One of the earliest forms of fixed supports was a tripod, composed of heavy poles—the spread at the base being proportioned to the depth—and, for increased stability, weighted with stone confined in pieces of wire netting. The tripods were dropped into position—from 20 to 50 ft. apart on the line of the dike—from a barge by a derrick. Later, piles were used: single piles in A-bents and vertical, and piles in clusters. Then followed in rapid succession: uniform and shorter spacing of vertical piles in single or multiple rows; the introduction of wales and braces for the transmission of strains; the use of foot-mattresses for protection against scour; and the substitution of gratings or curtains of poles for wire netting.

Thus was delevoped the form of permeable pile dike used so extensively in the systematic improvement of the river, and which is described in detail farther on.

Bank revetments.—The continuous, woven revetment, in its present form, as adapted for the protection of banks against erosion, is the outgrowth of years of experimentation:

First, with sectional mattresses of various kinds extending from the water's edge at the existing stage of the river 60 to 100 ft. into the stream, the upper bank being graded to a steep slope and covered with a thatching of brush, the latter held in place by wire or wire netting pinned to the slope.

The mattresses were composed of a grillage of brush held in place by top and bottom frames of poles or planks, the frames being fastened to each other through the mattress with pins and wedges, or wires, or both. In some cases an intermediate filling of grasses was put in. The first mattresses were made on fixed ways built in the bank at the head of the proposed revetment. As each section of mattress was completed, it was launched from the ways, allowed to make a quarter turn in the current, and then floated down to its position in the revetment, the first one going to the lower end of the work, the next one overlapping its up-stream edge, and so on, until the desired length of bank had been thus covered. Frequent loss of mattress, in transit from the ways to position in place, led to placing the ways on boats, from which the mattresses were launched directly into place.

Numerous failures of revetments made with sectional mattresses were found to be due, primarily, to their slipping or displacement from scour or other causes, thus breaking the continuity of the work and exposing all below it to loss by flanking. This consideration led to the adoption of continuous revetment. In one of the earliest forms, a continuous mattress, extending from the water's edge 112 ft. into the water, was made of a grillage of brush extensively sewed with wire and reinforced longitudinally with continuous brush fascines; the latter were sewed on top of the mattress, 5 ft. apart, in lines parallel to the outer edge. The first or bottom course of the mattress was made of willow brush, as compact as possible, laid across the ways, and normal to the bank line; the next or middle course was of scraggy, dogwood brush laid at right angles to the brush in the first course; and the third or top course was of willow brush laid across the brush in the middle course, only enough being used to bind and hold the latter in place. Thus, in effect, a continuous brush carpet was made, the warp, so to speak, being close and compact, the woof, open and cellular. The mattress was built, from the upper end down stream, on a boat provided with launching ways, from which the mattress was launched as made. Stone, about ⅓ cu. yd. per lin. ft., was used to sink the mattress.

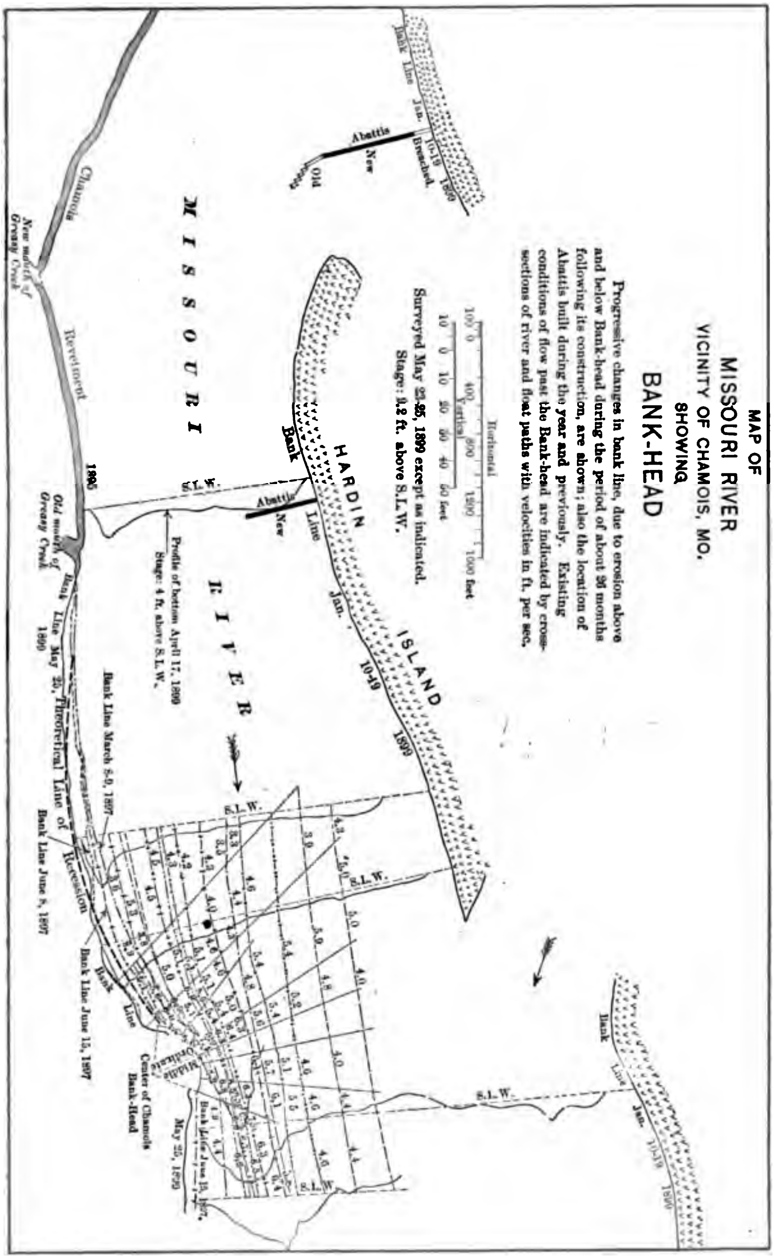
The upper bank was graded to a slope of 1 on 2½ and covered with a layer of brush 8 to 10 in. thick; a covering of earth about 8 in. thick was put on the latter, with a view of encouraging the growth of willows, and to protect it against loss by fire and abrasion by ice.

The particular piece of work here described was built in the fall of 1880, and, in the following spring, was subjected, without damage of any kind, to as severe an attack as any revetment could be, by the great flood of 1881. It is still intact, though for many years it has been masked by a shore bar.

Actuated by the thought that possibly such work was much heavier than necessary, some brief and convincing experiments were made with light, open works: A continuous wire netting, having rectangular meshes 2½ by 5 ft., in each of which was fastened a piece of scraggy, dogwood brush, was made in one piece, extending from the top of the bank, on a graded slope of 1 on 1½, about 80 ft. into the stream. The bank edge of the netting was fastened to stakes driven 5 ft. apart on top of the bank, and only 1¾ cu. yd. of stone were used in sinking 100 lin. ft. of it. This and similar constructions were quickly destroyed by the river.

Then the continuous woven mattress, first used on the Missouri River at Vermilion, S. Dak., came into general use. In early practice, the woven mattress, without reinforcement of any kind, extended from the top of the bank, on a graded slope, various distances into the stream. At one time the width of the mattress was such that, when in contact with the bottom, its outer edge would lie on the return slope, beyond the thalweg. Later, the mattress was strengthened longitudinally and transversely, first with large steel wires and subsequently with strands of smaller wires; and the transverse members were used to anchor the mattress to the bank.

Then the woven mattress was omitted from the upper bank, its inshore selvage lying at the foot of the graded slope just above water, and being held or anchored by short piles, spaced from 8 to 16⅔ ft. apart, with and without connecting wales. The upper bank



MAP OF
MISSOURI RIVER
VICINITY OF CHAMOIS, MO.
SHOWING
BANK-HEAD

Progressive changes in bank line, due to erosion above and below Bank-head during the period of about 26 months following its construction, are shown; also the location of Abattis built during the year and previously. Existing conditions of flow past the Bank-head are indicated by cross-sections of river and float paths with velocities in ft. per sec.

Surveyed May 23-25, 1899 except as indicated.
Stage: 1.2 ft. above S.L.W.

FIG. 1.

was protected with rip-rap, thrown on so as to cover it well. The next and final steps completed the development of what is now known as the standard revetment, and which is described in detail farther on.

In 1897 two new devices were introduced, both of which were designed by Colonel Amos Stickney, Corps of Engineers, at that time President of the Missouri River Commission.

One of these was a silt-catching device, called an "abattis" because of its similarity in form to the device of that name used in defensive military operations. It was first used as an auxiliary means of closing chutes, and proved so effectual that, later, it was also used for the advancement of shore lines in situations not exposed to the full forces of the river. Fig. 1, Plate III, shows the design and application of abattis.

The other device, called a "bank-head," was for use as a means of bank protection. The theory of the bank-head system was, that by the fixation of the bank at points some distance apart, the bank between those points would become stable after receding to a certain line, within reasonable, practicable limits; and that the resulting conditions of the flow in front of the structures and in the approaches would be free from objectionable features. The distance between fixed points was to be determined by experiment, but it was held that banks could be protected by bank-heads at a cost of one-third to one-fifth of that of revetment work.

The first bank-head was built in March, 1897, at the foot of Chamois Bend, 3 850 ft. below the lower end of a continuous revetment, the latter being 2¾ miles in length.

The arrangement of the structure is shown in plan and cross-section on Plate IV. The progressive changes in bank line due to erosion above and below the structure during the period of 20 months following its construction, and the resulting conditions of flow past it are shown in Fig. 1.

Plate V shows the bank-head nearing completion, and Fig. 2, Plate III, is a photograph taken after it had been exposed to the floods of two seasons. In form, the structure consists of segments of the frusta of two cones having a common axis, the lower one resting against the bank and on the bottom of the river, its top cut by a plane at an elevation of 6 ft. above standard low water, and

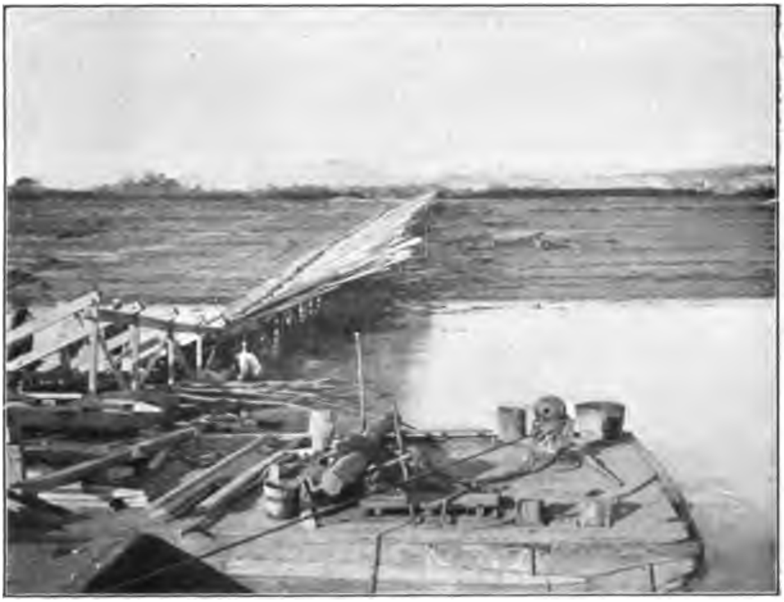


FIG. 1.—METHOD USED IN BUILDING A CONTINUOUS ABATTIS OVER WATER. LOOKING INSHORE.

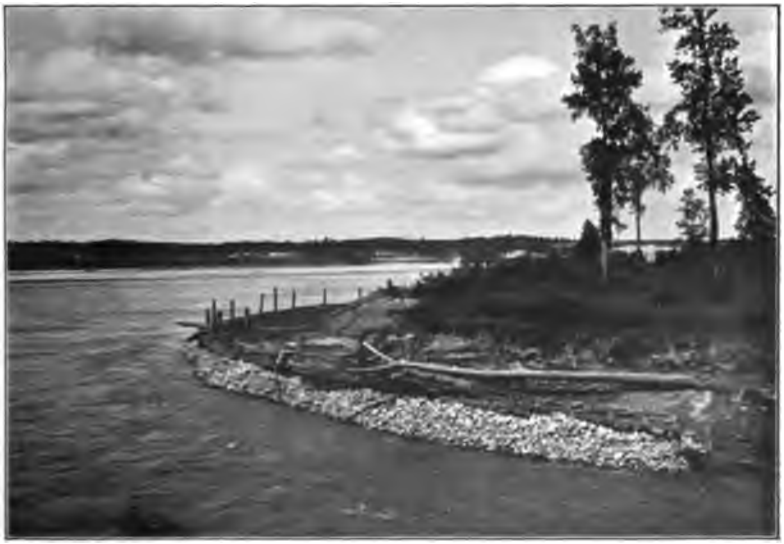


FIG. 2.—BANK-HEAD NEAR CHAMOIS, MO., LOOKING DOWN STREAM, AFTER STRUCTURE HAD BEEN EXPOSED TO THE FLOODS OF TWO SEASONS.

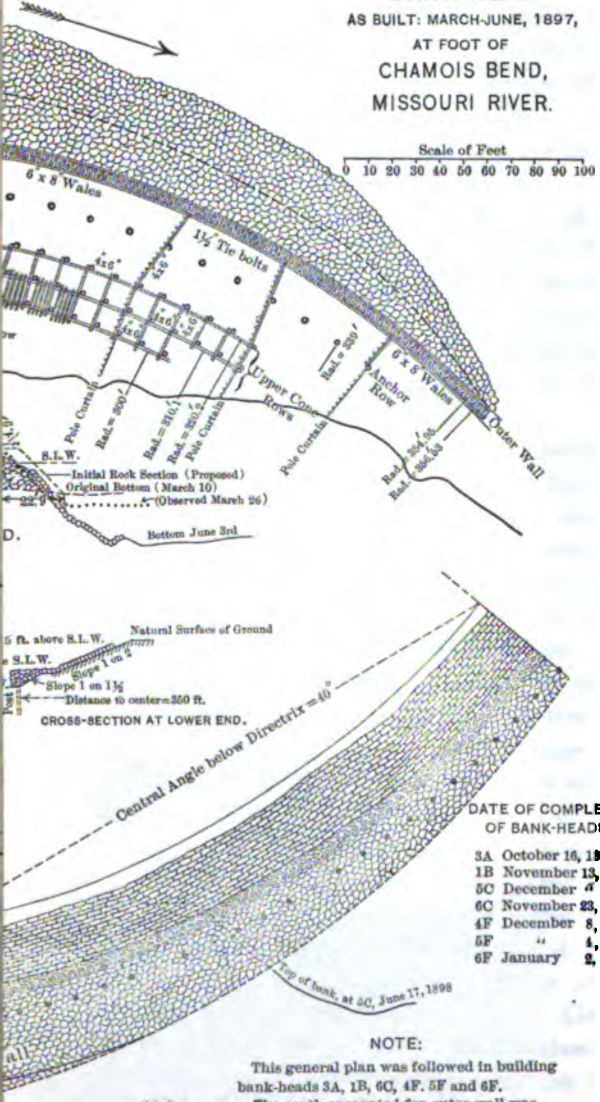
developing an arc of a circle 724.4 ft. in diameter and having a middle ordinate from the bank line of about 90 ft.; the upper frustum resting against the bank and on the lower one, developing an arc of a circle on the plane of contact therewith 640.4 ft. in diameter and from a common center. The top of the upper frustum is defined by the height of the river bank. The conical surface of the lower frustum is defined by the stone of the outer wall; that of the upper one by the pole screening.

Both surfaces, of course, were subject to change: the former from movement of the stone due to scour, which might finally leave the vertical wall of piles; the latter from accretions formed during stages of river in excess of 6 ft. above standard low water. In all, 608 piles were driven, as follows: 446 in the outer wall, 29 in the anchor row, 9 in the bank row, 109 in the upper-cone frustum, and 15 for temporary outside anchors. The piles in the outer row were driven to an average penetration of 22¾ ft., and all others to 20½ ft. It was intended that the piles in the outer wall should be driven 22 in. between centers in the rows, and that the rows should be 19 in. from center to center; but, because of the packing of the ground, due to jar as well as displacement, it was found impossible to drive them to the desired depth so close together. The distance apart in the rows, therefore, was increased to 3 ft. from center to center of piles, and brush was introduced between the piles, with a view of producing a practically tight wall. The specifications called for 3 400 cu. yd. of one-man stone in front of the wall. Of this quantity 2 467 cu. yd. were to be placed above the middle ordinate, in a practically uniform section of 250 sq. ft., and the remainder below, in diminishing section. In placing this, an effort was made, first to get on the bottom, as quickly as possible after the outer row of piles had been driven, a layer of stone 2.5 ft. thick and 22.9 ft. wide above the middle ordinate and diminishing from there below; thereafter the requisite quantity of stone per linear foot was simply thrown against the piles in the outer circle and allowed to find its slope. The space inside of the outer circle and the upper-cone frustum was to be filled by deposit from flood. For that purpose 1 497 lin. ft., or about 31 600 sq. ft., of curtains were built. One of these, on a line 30° up stream from the middle ordinate, was a tight curtain, made of 1-in. boards. The horizontal curtain, extending from the outer wall to the base of the upper-cone frustum, was made of wire netting, the meshes of which were practically filled with brush. The first cost of the bank-head was $11 265.13.

It was expected that the bank-head would hold the bank permanently at that point, and that, after a certain amount of recession, the stretch of free bank above it would become stable. It was expected that a scour in front of the bank-head would occur, and, based upon some experiments made with a model, the quantity of stone put in the outer wall was thought to be sufficient to follow up a scour of 50 ft., and that the stone would cover the resulting slope of the river bed so as to protect it against erosion. The form given the structure was thought to be such as would prevent, at all stages, the formation of violent eddies. During the period of fourteen months following the construction of the bank-head the bank above it continued to cave, the area of greatest erosion lying within a distance of 1 100 ft. above the structure. For about 1 000 ft. above the bank-head the shore line had receded back of the theoretical line of recession, forming a deep bay which terminated in a shoulder at the bank-head. At the latter point, measuring on the line of the outer wall of the bank-head, the bank had receded about 240 ft. This portion of the bank (for a distance of 1 100 ft. above the bank-head) then became comparatively stable until the fall of 1902, though, meanwhile, there was some bank caving all along from the bank-head to the foot of the revetment. During the two years following its construction, the bank-head was closely observed, and such repairs, reinforcement and extension as seemed necessary were made. The last extension of the outer wall, 44 ft. in length, was made in August, 1897, increasing the central angle of the structure to 103° 26′; but, by June, 1898, the bank had receded until a further extension of 110 ft. would have been necessary to connect the outer wall with the bank. This would have made the central angle of the bank-head 121° 16′. In March, 1899, two subaqueous spurs or groynes were added to the bank-head, extending from the outer wall into the stream about 150 ft. on radial lines 30° and 41° 27′, respectively, above the middle ordinate. The object of the spurs was to fill up the trench around the bank-head and prevent its formation again. For a short time the conditions were im-

PLATE IV.
PAPERS, AM. SOC. C. E.
JANUARY, 1905.
FOX ON
MISSOURI RIVER IMPROVEMENT.

PLAN OF
BANK-HEAD
AS BUILT: MARCH-JUNE, 1897,
AT FOOT OF
CHAMOIS BEND,
MISSOURI RIVER.



DATE OF COMPLETION
OF BANK-HEADS.

3A	October	16, 1897
1B	November	13, 1897
5C	December	" "
6C	November	23, "
4F	December	8, "
5F	"	4, "
6F	January	2, 1898,

NOTE:

This general plan was followed in building bank-heads 3A, 1B, 6C, 4F. 5F and 6F.

The earth excavated for outer wall was filled back 2 ft. above the actual surface of ground in bank-heads 3A, 1B and 6C. In the other structures this work was only partially done.

proved by the spurs, but they soon settled, and their effect was lost. In the fall of 1902 there was some caving of the bank above the bank-head, and by the following spring the shoulder immediately above it had deepened to such an extent that the structure was seriously threatened. Two spurs, built against the bank at the head of the structure, held it until the great flood of June, 1903, when the bank-head was flanked and destroyed.

During the fiscal year ending June 30th, 1898, nine other bank-heads were built in the Missouri River, as follows:

Three in Howard's Bend, above St. Charles, Mo., one above Rocheport, Mo., three above Glasgow, Mo., one near Miami, Mo., and one in Little Blue Reach, above Missouri City, Mo. Another bank-head, making eleven in all, was partially built at the foot of Little Missouri Bend, above Glasgow. It was never completed, and, though not in the line of flow, has been practically destroyed. The bank-head above Rocheport was destroyed in June, 1902.

With the exception of the Chamois bank-head, already described, the one in Little Missouri Bend and the structure above Rocheport, all these bank-heads were first built under a general plan, as shown on Plate IV. It will be noticed that, while the form was similar to that of the Chamois bank-head, the use of piles was done away with, stone only being used, and the structure was set back so that when completed it was almost entirely masked by the bank. It was thought that, until it was uncovered by erosion, its effect upon the flow would be gradual, permitting the river to accommodate itself to the restraint without producing any violent change of regimen. The floor of the rock wall was excavated to the level of standard low water, as nearly as practicable; the inner line of the floor was an arc of a circle of 350 ft. radius, located so as to be tangent to the standard low-water contour of the bank. This line was defined on the ground, for guidance during construction and for subsequent reference, by 6 by 8-in. posts, 10 ft. long, driven 10 ft. apart on the circle, and to a depth of about 5 ft., or until their tops were at or near 5 ft. above standard low water. Above the directrix, the floor was excavated to a width of 27½ ft., where it fell entirely within the bank; in front of the post circle, on the floor where it fell within the bank and in the water or the foreshore outside of the bank, 125 cu. ft. of rock per linear foot were placed;

below the directrix, the quantity of rock was gradually diminished to 12.5 cu. ft. per linear foot at the lower end, the width of the excavation varying to give the specified cross-sectional area within the uniform depth of 5 ft. for the rock wall. Inside the post circle the bank was graded to a slope of 1 on 1½ to an elevation of 4 ft. above standard low water, then a 4-ft. berm was made, from which the bank rose to the surface of the ground on a graded slope of 1 on 2; the space back of the post was filled with stone, and the berm and slope were paved to a thickness of 1 ft., the latter up to a height of from 15 to 20 ft. above standard low water. After the stone was in place, the excavation was generally filled back to an elevation about 2 ft. higher than the natural surface of the ground, and the remaining earth excavated was wasted in front of the bank-head.

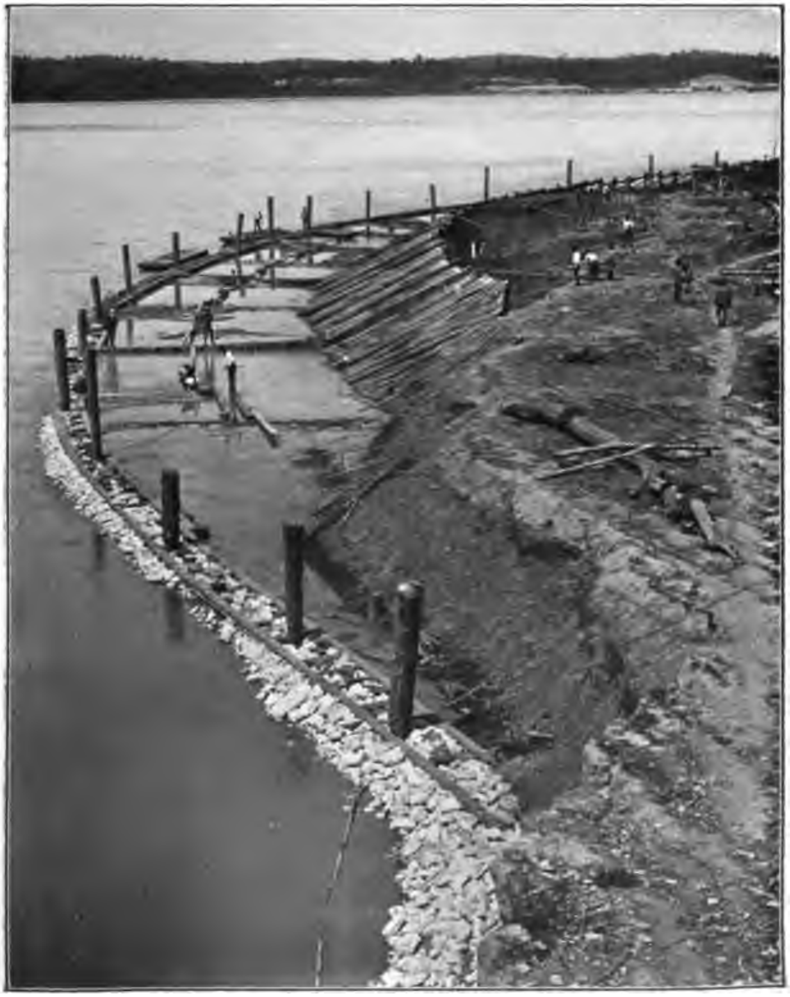
A somewhat modified form of construction was adopted in building the bank-head above Rocheport, *viz.:* The excavation was made entirely within the bank; its floor, or the bottom of the wall, was made 15 ft. wide and at an elevation of 10 ft. above standard low water; the outside line of the floor was an arc of a circle of 315 ft. radius, located tangentially to the 10-ft. contour of the shore; a section of the rock wall was a parallelogram, 150 sq. ft. in area throughout, 15 ft. wide on top and bottom, 10 ft. high, with side slopes of 1 on 1. Fig. 1, Plate VI, is a photograph of this bank-head as subsequently remodelled.

Fig. 2, Plate VI, is a photograph of Bank-head 1 B, near Miami, Mo., as subsequently remodelled and extended.

It developed early in the history of these structures that, in their original form, they would not withstand sharp attack by the river. All but two of them, in the upper part of Howard's Bend, were remodelled and, subsequently, extended, reinforced and repaired; and, in the majority of cases, auxiliary structures, in the way of pile dikes and abattis, were built to protect the bank-heads and to ameliorate undesirable conditions of flow past them.

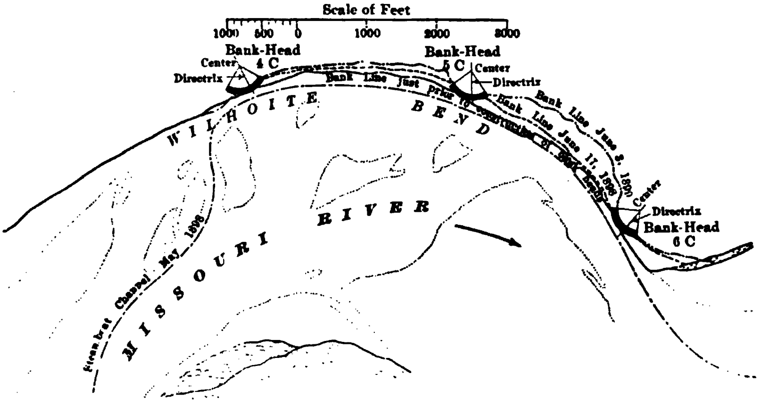
By these means, involving an expenditure of a sum of money largely in excess of original estimates, and the loss, meanwhile, of considerable land, the three bank-heads in Wilhoites Bend, above Glasgow, were maintained, and conditions of flow developed that, for a time, were highly satisfactory. Fig. 2 is a map of the Missouri River, showing the system of bank-heads, and Fig. 3 shows the results of treatment by this method.

PLATE V.
PAPERS, AM. SOC. C. E.
JANUARY, 1905.
FOX ON
MISSOURI RIVER IMPROVEMENT.



BANK-HEAD NEAR CHAMOIS, MO., NEARING COMPLETION. LOOKING DOWN STREAM.

There was reason for belief that, after some further experimentation, on lines suggested by the experience gained, a satisfactory system of bank-head protection could be devised; but, at this juncture, appropriations failed, and the ultimate success of bank-heads, as a practical, economical means of bank protection on the Missouri River, yet remains to be demonstrated.



MAP OF
MISSOURI RIVER ABOVE GLASGOW, MO.
SHOWING A SYSTEM OF
BANK-HEADS

As originally built within the bank during the fiscal year of 1898;
also extent of subsequent erosion of the bank to June, 1899.
Later, the bank-heads were remodelled, extended and reinforced,
and, auxiliary structures were built.

FIG. 2.

DESCRIPTION OF MORE IMPORTANT DIKES AND REVETMENT.

Systematic Improvement.—The most important work on the Missouri River is that done since 1891 by the Missouri River Commission in the systematic improvement of 45 miles of the upper portion of First Reach, extending from 4 miles above Jefferson City to the mouth of Gasconade River, the latter being 110 miles above the mouth of the Missouri.

This was one of the worst reaches on the river, presenting, not only a category of characteristic conditions, but especially difficult conditions at the mouth of Osage River.

The proposed widths of the improved river were: Above Portland 1 000 ft. between standard low-water contours, and 1 140 ft. between standard high-water contours; below Portland 1 100 ft. and 1 240 ft., respectively.

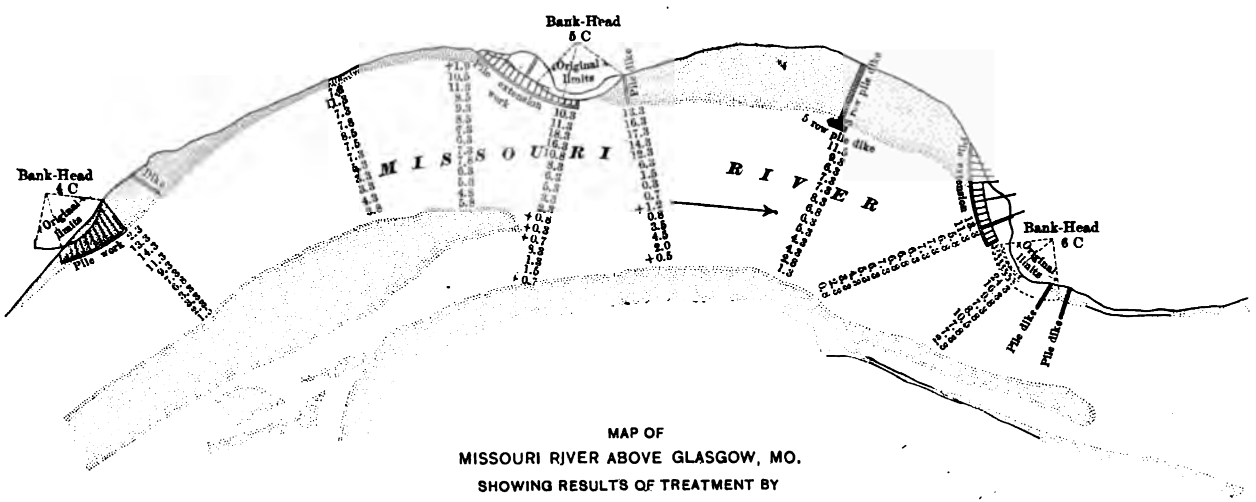
The total cost of the improvement of the 45 miles of river was $2 500 000, or a little less than $56 000 per mile.

The results obtained were highly satisfactory. A continuous channel, conforming closely to project lines, and with a minimum low-water depth increased from 2½ to 6 ft., was made; and new banks were aligned and well advanced in the process of building up to desired heights. Incidentally, large areas of land were reclaimed, to say nothing of land protected.

Although the works and results have suffered by neglect, they amply justify the statement that the improvement of the river is entirely feasible, and at a cost per mile much less than that which has been improved. "The work at the mouth of Osage River was exceedingly difficult and costly; nothing like it is to be expected at any other point on the river." Furthermore, "the work was largely experimental, and the experience gained will unquestionably render possible a very considerable reduction, both in the extent and cost of future work."

Permeable Pile Dikes.—These structures consist essentially of one or more rows of piles, as indicated by the exposure to which the dike will be subjected, the piles being driven, or sunk, to such penetrations as will, with a given system of bracing for the transmission of strains, develop their full strength; provided with a foot-mattress for protection against scour; and screened or curtained to check flow through it and thereby cause deposit.

When applied to the advancement of a bank out to the proposed line of rectification, these structures are built from the existing bank out, on a line bearing slightly down stream from a normal to the flow. The practice, as to height of dikes, differed on the two divisions, and varied from time to time; but, in the main, they were run out level with the top of the bank, or 2 ft. above standard high water, to near the standard high-water contour of the proposed recti-



MAP OF
MISSOURI RIVER ABOVE GLASGOW, MO.
SHOWING RESULTS OF TREATMENT BY
BANK-HEADS

As developed from Survey of Sept., 1901, nearly 4 years after original structures were completed. The location and character of extensions to the original bank-heads, and of the auxiliary structures found necessary to bring about the results, are also shown.

Scale of Feet
0 400 800 1200

Stage of river 1.7 to 1.5 above S.L.W.
All soundings reduced to S.L.W.

Fig. 8.

fied shore, and from there they sloped down to as near 2 ft. above standard low water as the stage of river at the time permitted.

When located on the bar side of the river, or the convex side of bends, the exposure is generally, or at least frequently, such that the dike is made of increasing strength from the bank out, *i. e.*, commencing at the bank with 1-row work and changing successively to 2-row, 3-row and 4-row work as the exposure increases with distance from the bank. When located on the concave side of bends, the dikes, on account of the exposure, are seldom of lighter construction (fewer rows of piling) at their bank ends, than at their stream or outer ends; and in some instances the heaviest construction is near the bank. This was found necessary wherever the thalweg was close to the bank, and pile penetrations were limited by excessive depth of water, impenetrable bottom, or other cause. The lower dikes of a group of dikes were made of lighter construction than the one farthest up stream, excepting that portion of each which projected beyond the influence of the dike next above it. The outer ends of all dikes, for a length of from 50 to 200 ft., were reinforced: usually by additional piles driven alongside the upper pile of each bent; by additional top diagonal braces; and by increasing the width of the foot-mattress from 5 to 10 ft. on the up-stream side. In order to strengthen still more the outer ends of dikes, to ameliorate the eddy action there and to cause the deposit to form as far out as possible, all dikes were provided with a head, of one of the following forms: A wing or trail of 2-row pilework, similar in construction to the main structure and extending down stream from 60 to 100 ft. or more; T-shaped heads of like construction extending above as well as below the dike; heads formed by a cluster of three piles 20 ft. above and another cluster 20 ft. below the stream-end bent space, the clusters being connected to the outer two bents of the dike by wales.

Fig. 1, Plate VII, shows one of a group of dikes built from the concave side of the river where the penetration of the piles for some distance from the bank was limited by bed-rock. It is provided at its stream end with a 2-row T-head. Some views of other dikes are given on Plates VIII and IX.

When located within a chute, for the purpose of closing it, the dike, of course, extends across the chute from bank to bank at bank

PLATE VI.
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JANUARY, 1905.
FOX ON
MISSOURI RIVER IMPROVEMENT.

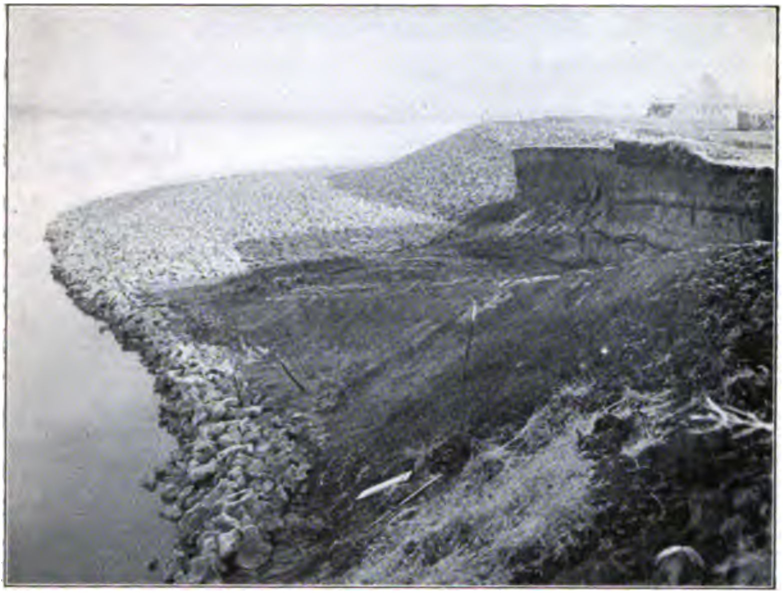

Fig. 1.—Bank-head above Rocheport, Mo., as Remodeled. Looking Down Stream.

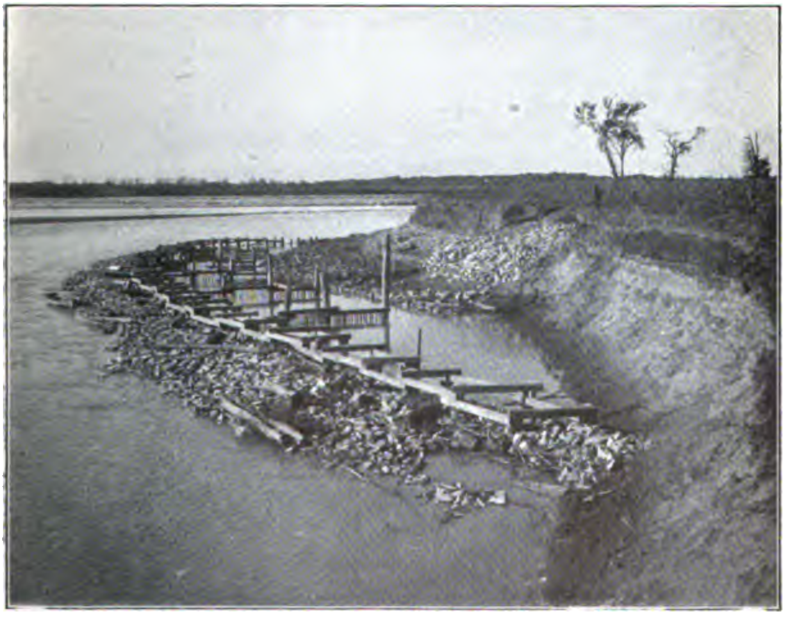

Fig. 2.—Bank-head near Miami, Mo., After Remodeling and Extending. Looking Down Stream.

height; and when, as is generally the case, the structure is exposed to active high-water flow, the upper dike, if more than one be used, is very substantially built. Especial attention is given to make the shore ends of chute dikes secure against flanking by erosion which may develop in the event of the release of head on the structure. In especially difficult situations, or where the head upon the structure would otherwise be very large, the spacing between the poles of the curtain is rapidly increased from both banks toward mid-width, or, the curtain is omitted for several bents near the middle of the structure.

The specifications which governed the dikes constructed on the two divisions of First Reach differed in details, and were changed from time to time. The following specifications, drawn up on June 23, 1896, embody details, some of which were peculiar to the practice on each division and some common to both. As a whole, they represent what was considered at that time the best practice:

"SPECIFICATIONS."

"The most natural sequence in which the different branches of dike construction are carried on, is as follows: Pile-driving, construction of foot-mattress and sinking of the same, bracing, screening and lashing. The specifications for each of these operations are given below in the order named:

"*Pile-driving.*—The piles shall be driven in rows 10 ft. between centers, the rows being 10 ft. between centers. The number of rows shall be from one to five according to the anticipated exposure, or limitation of penetration. All piles shall be driven to a penetration of not less than 25 ft., unless limited by bed-rock. In cases where bed-rock limits penetrations to less than 20 ft., the desired stability is to be secured by increasing the number of rows, or, when limited to less than 15 ft., by filling in with stone. In special cases where excessive scour or great stress is anticipated, as at the stream ends of dikes on a concave shore, or the upper dike of any group, penetrations up to 35 ft. may be necessary.

"For 10 bents inshore from the head, the upper row of piling should be reinforced at each bent by an additional pile driven close and lashed to it.

"Piling shall be of such lengths that when driven to their specified penetrations their tops shall be not more than 1 ft. below or above grade.

"*Foot-mattress.*—The foot-mattress shall be of standard type, compactly woven, and not less than 12 in. thick, the width of mattress and its reinforcement by galvanized steel strand being as specified below.

"The width shall be 30 ft. for 1-row dike, 40 ft. for 2-row, 55 ft. for 3-row, and 65 ft. for 4-row, and shall be increased 10 ft. for each row in excess of 4-row. The upper selvage edge must extend 20 ft. above the upper row of 1- and 2-row work, and 25 ft. above for 3-row work and upward, the above widths being increased 10 ft. on the upstream side of the dikes for a distance of 100 ft. from their outer ends.

"The foot-mattress must extend from the bank at the shore end, at an elevation there of 6 ft. above S. L. W., to 40 ft. beyond the outer row of piles of the dike head at the stream end, and along the head 20 ft. beyond each of its extremities. The width of mat at the head shall be 70 ft. The mattress shall be reinforced by ⅜-in. strand longitudinally and transversely, as follows: One-row work shall have a single strand in each selvage, and a single longitudinal 8 ft. above the piles; 2-, 3- and 4-row work shall have a single strand in each selvage and a single longitudinal 8 ft. above the upper row of piles; all mattress shall have transversals of double ⅜-in. strand across the mat from selvage to selvage, midway of alternate bents, the transversals being pin-twisted or toggled at the intersections of longitudinals and on the lines of piling, and the longitudinals being pin-twisted or toggled at intersections with transversals and at intermediate points between transversals. The same spacing of strand and other specifications shall apply to the mattress in and beyond the dike head.

"The mattress shall be sunk to close contact with the bottom throughout, a sufficient quantity of ballast being used to insure this. In no case shall a less quantity than ½ cu. yd. per 100 sq. ft. of mattress be used.

"In addition to the stone above specified, 50 cu. yd. shall be distributed on the outer 100 ft. of the main dike and 25 cu. yd. on each 100 ft. of the dike head, the stone ballast being in fragments weighing not less than 20 nor more than 60 lb. and no stone being less than 3 in. thick.

"For temporary anchorage during construction, single piles shall be placed not less than 60 ft. above the upper row of dike piles, the distance between the piles being governed by the depth of water and velocity of current.

"*Bracing.*—The bracing system shall consist of wales placed longitudinally, and braces placed transversely to the dike, the latter being divided into three classes, *viz.:* 'direct transversals,' 'diagonal transversals' and 'drop transversals.' All bracing shall be long-leaf

PLATE VII.
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FOX ON
MISSOURI RIVER IMPROVEMENT.

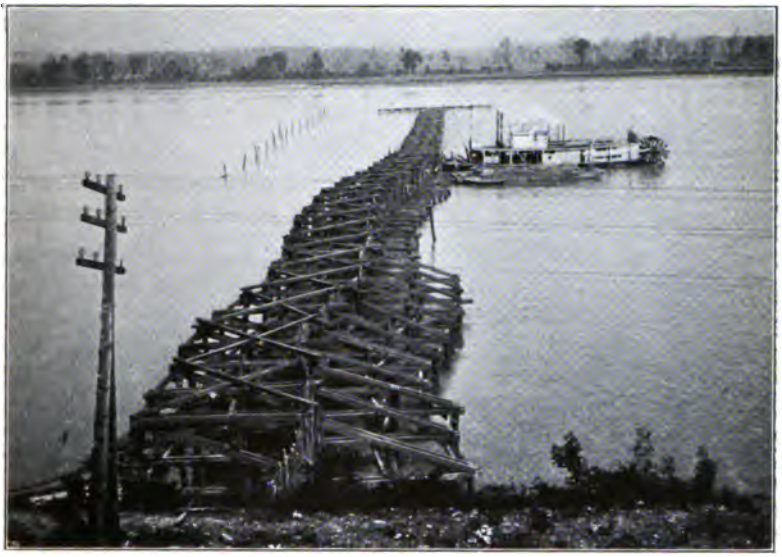


FIG. 1.—DIKE 1 B, PRACTICALLY COMPLETED.

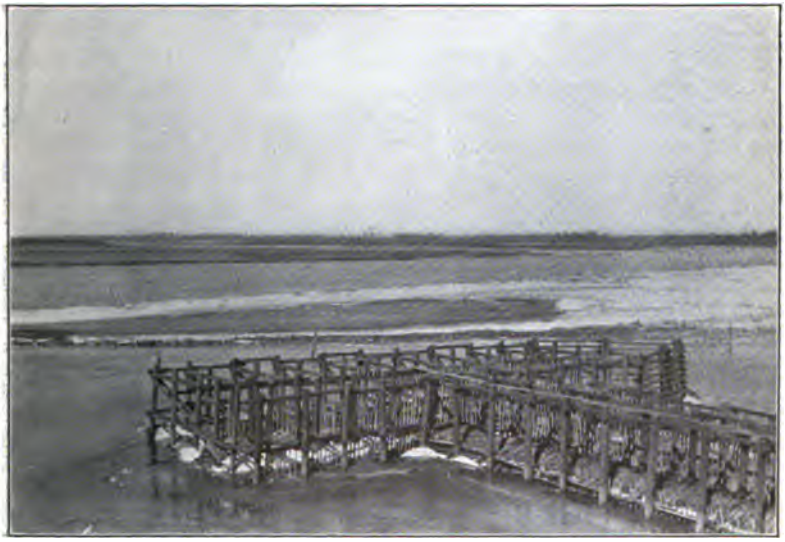


FIG. 2.—T-DIKE, IN WILHOITE BEND.

yellow pine. The wales are to be bolted on the up-stream side of each row of piles, and are to be uniformly 6 by 8 in., and 22 ft. long.

"Direct transversals, consisting of two pieces, 3 by 8 in. by 22 ft., for the upper three rows, and 3 by 8 in. by 12 ft. or 22 ft., for additional rows, as may be necessary, shall be bolted to the sides of each pile.

"The direct transversals shall be gained 1 in. at each end to take the thrust from the upper and transmit it to the lower wale.

"In the construction of dikes located on cross-sections of river, the high-water widths of which are 3 000 ft. or less, the direct transversals will be placed under the wales; for dikes beyond the 3 000-ft. limit they will be placed on top of the wales.

"Diagonal transversals, 5 by 8 in. by 16 ft., shall be drift-bolted to the tops of the piling. These braces are to be laid on the upper three rows, forming a single intersection for the full length of the upper dike of all groups, or, for isolated dikes. They are also to be used for the outer 150 ft. of all dikes, and for that portion of a dike on a concave shore which projects beyond the dike next above. This diagonal transversals are to be also used for bracing the dike head.

"For dikes outside the 3 000-ft. limit a double system of bracing shall be used, the upper of which is to be in all respects similar to that described above for dikes within the 3 000-ft. limit, with the exception already noted, as to the relative positions of the direct transversals and wales, and the further exception that the diagonal transversals are to be omitted. The members of the lower system are to be the same as those of the upper system, and placed 8 ft. below them. A drop-transversal, consisting of two pieces, 3 by 6 in. by 24 ft., extending from the top wale of the upper row to the lower transversal of the third row, is to be introduced at each bent and bolted to each pile.

"All wales and braces, except diagonal transversals, are to be fastened to the piles with ⅞-in. screw-bolts. The diagonal transversals are to be fastened with ¾-in. drift-bolts.

"*Lashing.*—The top system of bracing shall be lashed together at the piles with ⅜-in. galvanized-steel strand throughout the entire length of all upper dikes, and on their heads, and on all other dikes and their heads, wherever diagonal transversals are used.

"*Screen-Work.*—Screens shall be formed of poles placed on the next to the lower row of dike piling and middle row of dike-head piling. The poles are to have butt diameters not less than 2¾ in. nor more than 5 in. The spaces in the clear between adjacent poles must vary from 2 to 6 in. The poles are to be sharpened, driven well through the mat, and fastened to the up-stream side of the wale with wire nails.

"When additional supports for the screen poles are required, on account of excessive depth or current velocities, such supports are to be given either by ⅜-in. wire strand or poles fastened to the piling.

"In cases where circumstances prevent the procuring or use of poles for screen work, wire netting, placed in front of the upper line of piling, and with area of mesh of about 24 sq. in., shall be used.

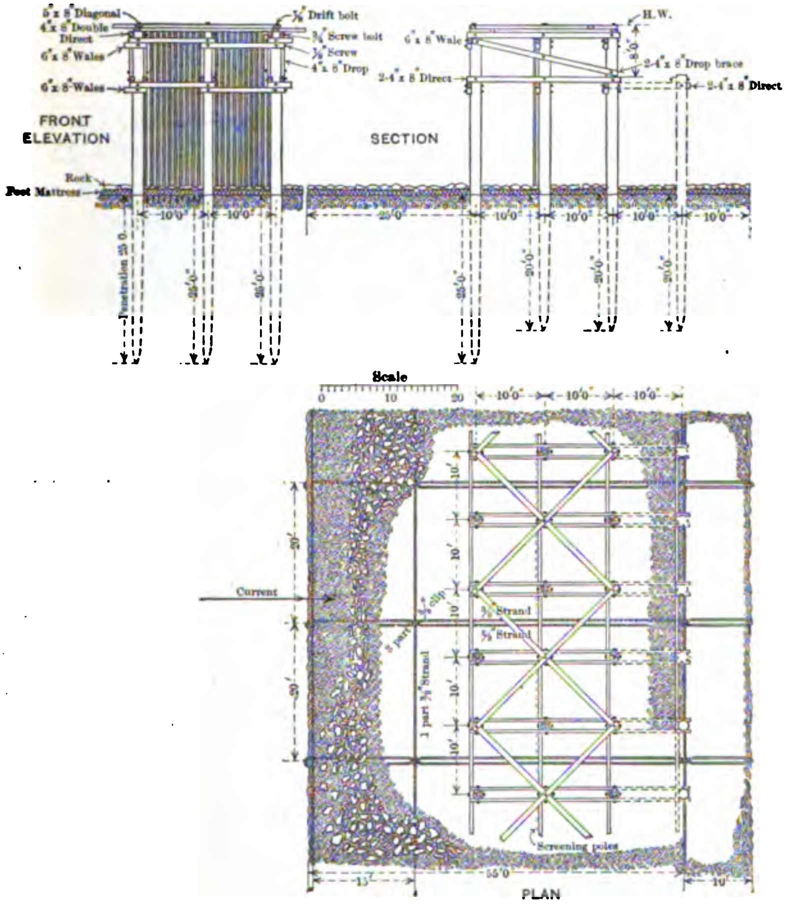
"After the outline of the accretions becomes defined, or within a period of three years after the completion of the dike, that portion of the dike beyond the accretions shall be reinforced by filling in with mattress and stone, to form a submerged spur extending on an approximately uniform slope about 40 ft. beyond the dike head."

Fig. 4 shows the typical 3- and 4- row dike, as built during the period from 1891 to 1897.

After the foregoing specifications were formulated, three details which added to the strength and efficiency of pile dikes were adopted:

First.—All double, direct braces were provided with filling blocks, 30 in. long, fitted close up to the pile at each end of the brace, and held in place by two ¾-in. screw-bolts. The object of this device was to relieve or reinforce the bolts which fasten the brace to the pile.

Second.—Wire-strand ties were used, to transmit stress from the top of a dike in the lower row to the base of the structure at the upper row, thus adding a measure of stability previously obtained by the more expensive method of double-system bracing, or an additional row of piles. The ties are of several parts of ⅜-in. strand, or, one or more parts of ¾-in. strand, as indicated by the stress. They are usually attached to the upper pile before driving, at a point which when driven will be on or near the bottom, a round turn being taken on the pile and the bight of it being fastened there by a staple; if it be a single-part tie, the short end is clipped on the other, close up to the pile, and the tie, whether of one or more parts, is then lashed up alongside of the pile until the foot-mattress shall have been sunk in place, when it is made fast at the top of the pile in the lower row. Several devices were used to obtain proper tension on the tie when in place. If composed of two or more parts, they were pin-twisted, after being made fast, until as taut as desired, and then the pin was lashed and left on the tie. One of the simplest and best methods for making one-part ties taut is, first to make the tie fast with as little slack as possible without the use of



TYPICAL 3-AND 4-ROW DIKE AS USED 1891 TO 1897.

The latter being in all respects like the former.
With additional work shown in dotted lines.
In low dikes, or those not greatly exposed,
the lower system of bracing is omitted.

Fig. 4.

tools, then, with a spreader, composed of a jack and block placed on the direct brace, spread apart the tie pile and the one next above it in the same bent, until the tie is under the desired tension, then place the filling block in the down-stream end of the direct brace close up against the tie pile, and, finally, bolt the brace to the tie pile before removing the spreader.

Third.—The spacing of the poles forming the curtains of cross-dikes was given wider range, and, except in special cases, was made to increase uniformly and rapidly from the bank out; those in the shore-end bent space were placed in juxtaposition, or, say, from 24 to 28 poles were used; in succeeding bent spaces the poles were spread apart increasingly, to the extent indicated by local conditions. In special cases, where it was desired to invite the flow to move quickly from one part of the structure to another, the former was more closely curtained than the latter, or, the curtain was omitted on the latter part. Plate X shows the general plan and details of 3- and 4- row pile dikes as built subsequent to 1897.

Numerous other bracing devices were tried, with a view of economizing in material and cost of building, without impairing the strength and efficiency of dikes, but without marked success.

Miniature bents of dike work—about one-third size—of various forms, old and new, were erected on shore, and subjected to known stress until broken or overturned. The most interesting of the developments from these experiments was the apparent utility of a ground-brace, *i. e.*, a direct transversal at the river bottom. Such braces were introduced on a number of dikes in the upper reaches, but no special report as to their efficiency was made; and the difficulty and cost of placing them led to their abandonment. The experiments clearly demonstrated the superior efficiency of a simple division of the bent quadrilateral into two triangles with double, direct braces in which filling blocks were used, and diagonal ties of galvanized strand. Additional members involved ambiguity of stress, owing to the character of the construction.

There are two things which mar the efficiency of pile cross-dikes:

First.—Immense quantities of drift-wood, borne on the surface and at all depths during flood stages, find lodgement to a greater or less extent in unevenly distributed masses upon the structures. This

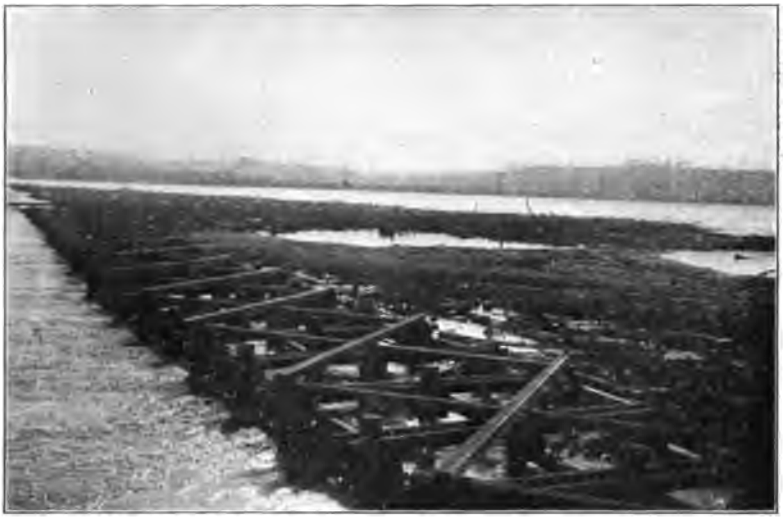


FIG. 1.—PILE-DIKE, OPPOSITE CHAMOIS, MO., WHILE IN FLOOD, SOON AFTER COMPLETION.

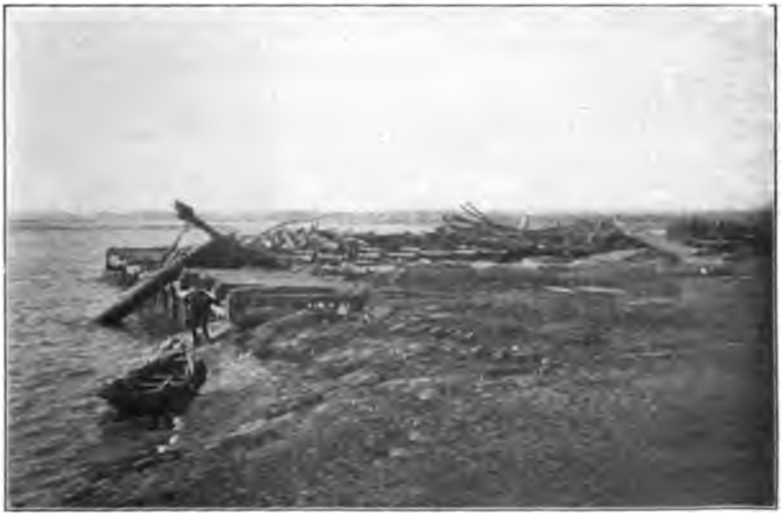


FIG. 2.—PILE-DIKE, OPPOSITE CHAMOIS, MO., SHOWING ACCRETIONS FORMED BY THE DIKE WITHIN A FEW DAYS AFTER COMPLETION.

often results in breaching the dike, by overturning it, or, by crushing the structural parts; scour, introduced by concentrated flow, or excessive head, may be a primary, or, contributory cause, and, of course, once a breach is formed it rapidly widens, due to scour, until head has been dissipated to such an extent that velocities are reduced below that at which scour can take place. Even though the structure be not breached, its curtain may be rendered practically inoperative by drift-wood, so that the flow through the dike is very uneven and the deposits formed are correspondingly irregular.

Second.—There is always more or less of a pot-hole or trench at the stream end of the dike, which attracts the flow and prevents the formation or maintenance of deposits quite out to the end of the structure; more or less eddy action is in persistent attendance, and, as the structure deteriorates with age, constant exposure to the forces of the river is more and more likely to destroy it; and, once the outer end of a dike is destroyed, the remaining portion yields more readily. Scour at the stream ends of dikes is first caused by increased velocity due to release of head on the structure. The pot-hole or trench is formed and maintained as the result of scour in the presence of a fixed object of limited extent; and the form, area and depth of the pot-hole depend upon the form and extent of the structure, the head due to the resistance it offers to flow, and the character of the river bed at that place.

Initial scour having occurred, flow is attracted, and, because of the fixed object (the outer end of the dike), velocity and, therefore, scouring capacity are increased. Increase in depth and velocity is followed by decrease of local width. A bar, or reef, over which the attracted flow pours into the deepened section, moves down toward the structure, increasing the scouring effect and continuing to advance until its lower face is swept by a current strong enough to carry away, as fast as contributed, the material brought in over its crest. The pot-hole or trench thus formed is defined on one side by the bar, and on the other by the structure, and it conforms somewhat to the latter. The trench extends but a short distance beyond the structure, being most pronounced in front of it, or slightly below the point of strongest impact against the structure. Easement of flow is found immediately below the dike, and the slackened current being unable to carry the materials scoured out from, or brought through, the trench, drops them, forming a bar; and the tendency is for the flow to divide on the bar, forming two waterways. The location, height and extent of the bar, and the predominance of one or the other of the two waterways depend largely upon the form and size of the structure, but vary also with stage, approach and other elements of flow.

It will be seen, therefore, that in reaches of river requiring advancement of both banks, the use of cross-dikes will result in a more or less divided flow; the cross-section of a reach so treated will be characterized by shallow mid-stream depths and relatively greater depths along both banks. In straight reaches, the flow may approximate an equal division along each bank; in curved reaches, up to the limits of curvature when chording effect is operative, the flow would be increasingly on the concave side.

Several devices have been tried with a view of remedying or ameliorating these effects, but with only a small measure of success.

In addition to the dike heads previously mentioned—trails and T-shaped heads of pilework similar to the main structure, and pile-cluster heads—short, subaqueous spurs of rip-rap, and curved heads of pilework have been tried.

The stone spurs referred to were built at the outer ends of the upper two dikes of a group in First Reach.

The result, after several seasons' exposure, was the formation of two pot-holes at each dike, one above and one below the spur, connected by a trench around the end of the spur. Each of the new pot-holes, however, was of smaller area and less depth than the original one, and the trench was not sharply defined. There was a gradual degrading of the spurs, apparently due in part to scour along their up-stream sides.

Two dikes with curved ends, of pilework, were built in the vicinity of Nebraska City. It was expected that, in such form, the flow about their ends would be eased, making less eddy and causing the accretions to form nearer to the channel lines; also that heavy drift-wood would not accumulate against them. They were designated and are hereinafter referred to as Dikes Nos. 3 and 5. Both are located on the left bank, opposite Nebraska City, Neb., Dike No. 3 being 1 425 ft. above Dike No. 5. Both structures are at

PLATE IX.
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FOX ON
MISSOURI RIVER IMPROVEMENT.

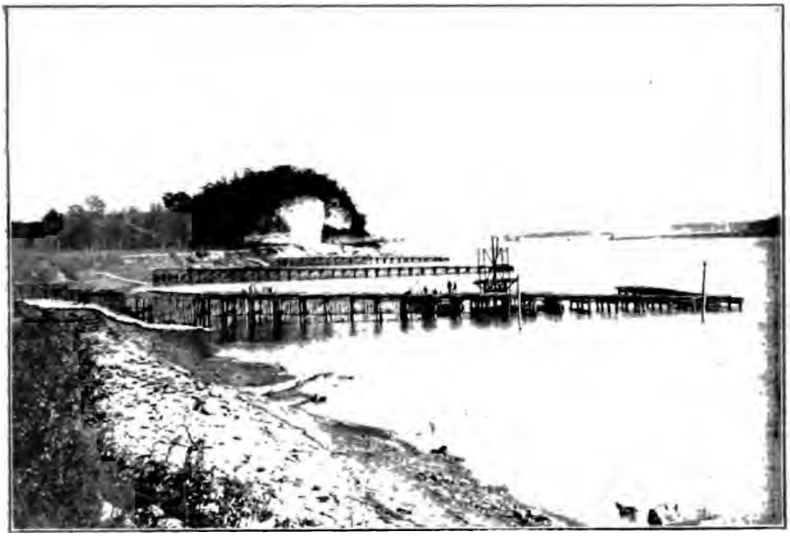


FIG. 1.—LITTLE TAVERN DIKES, NEARING COMPLETION.

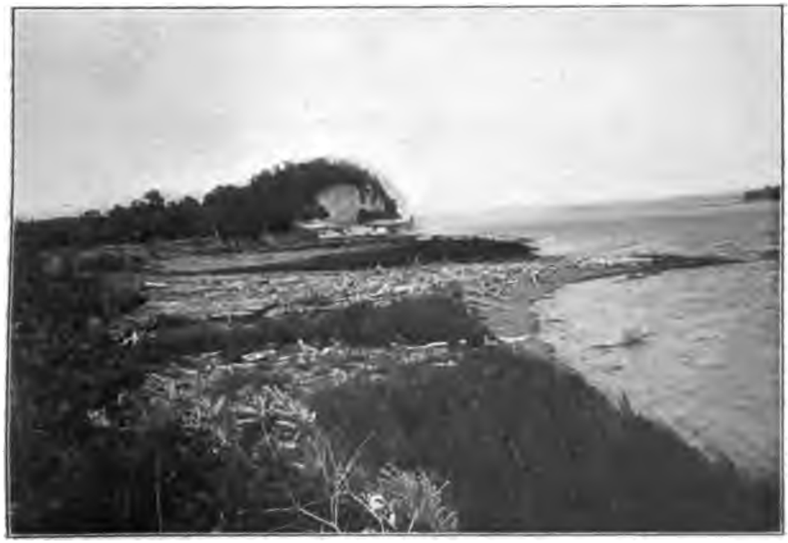


FIG. 2.—ACCRETIONS DUE TO LITTLE TAVERN DIKES, AS THEY APPEARED TWO YEARS AFTER COMPLETION OF THE DIKES.

M 70 U

times subjected to severe attacks by the river, Dike No. 5 oftener and more severely than Dike No. 3.

Dike No. 3 was built in November, 1897, and is an extension to Stub-dike No. 3, constructed in May, 1897. It is in the form of a circular arc, 400 ft. in length, with a radius of about 340 ft. It is composed of 3-row work, except the lower 100 ft., which is 2-row work.

Dike No. 5 was originally built during March and April, 1898. It was formed of 80 pile-bents of 2-row work, 37 of which extended from the shore about normal to the flow; the remaining 43 bents formed the curved trail, made as a circular arc of 340 ft. radius.

Soon after the completion of Dike No. 5, there were several sharp rises, which caused extensive accretions to form under both dikes. Both structures were practically free from drift-wood.

Dike No. 3 is still intact, and has caught but little drift-wood; but the accretions formed by it have not been maintained, and are deficient.

During the June rise of 1899, the outer end of Dike No. 5, including practically all the curved portion, was carried away.

The rebuilding of a curved end, of new design, was commenced in November, 1899, but a combination of adverse causes—insufficiency of available plant and delays in receiving construction materials—held the work back until increased cost and loss of some of the work, due to severe weather conditions, forced a suspension of operations, with the structure incomplete.

The dike was completed in April, 1900, though not as designed, the foot-mattress being curtailed in width and length.

As rebuilt, it was composed of six concentric rows of piles, braced, provided with foot-mattress, and screened. The outer row of piles was on the arc of a circle of 800 ft. radius; the other rows were spaced radially inshore 10, 15, 15, 10 and 15 ft., respectively, between center lines, commencing with the outer row. The piles in the outer row were spaced at 10-ft. centers, and those in the other rows fell on the radials therefrom, except in the third and fourth rows, where piles were placed only on every fourth radial.

The outer row passed through Bent 44 of the original structure, and was 660 ft. in length, its up-stream end being 80 ft., on the circular arc, above Bent 44, and its lower end lying at the point of tangency of the 800-ft. circle to the proposed line of rectification. The grade of the two inner rows—735 and 750 ft. radius—was level and at standard high water; the other four rows were built to a level grade 5.66 ft. lower, forming a flat level berm, 50 ft. in width throughout and 3 ft. above standard low water. Ten bents of 2-row pilework, with 10-ft. spacing, were built to a level grade, at standard high water, on a radial line through the eighteenth bent above the lower end of the structure, extending 108 ft. inshore from the 735-ft. curve.

Below Bent 43 of the old dike, the foot-mattress was suspended from the piles in the 735-ft. curve at standard low water. It was intended that the foot-mattress should have a total width of 155 ft., extending from 15 ft. inside of the inner row of piles to 75 ft. beyond the outer row; and it was made thus for about one-half the length of the curved head from the up-stream end. Below that, to the fourteenth bent from the lower end of the structure, the width of mattress outside of the outer row was curtailed, first to 60 ft., then to 45 ft.; and below the fourteenth bent the mattress in front of the dike from the lower end was omitted, the outer row of piling being just inside the selvage edge of the mattress.

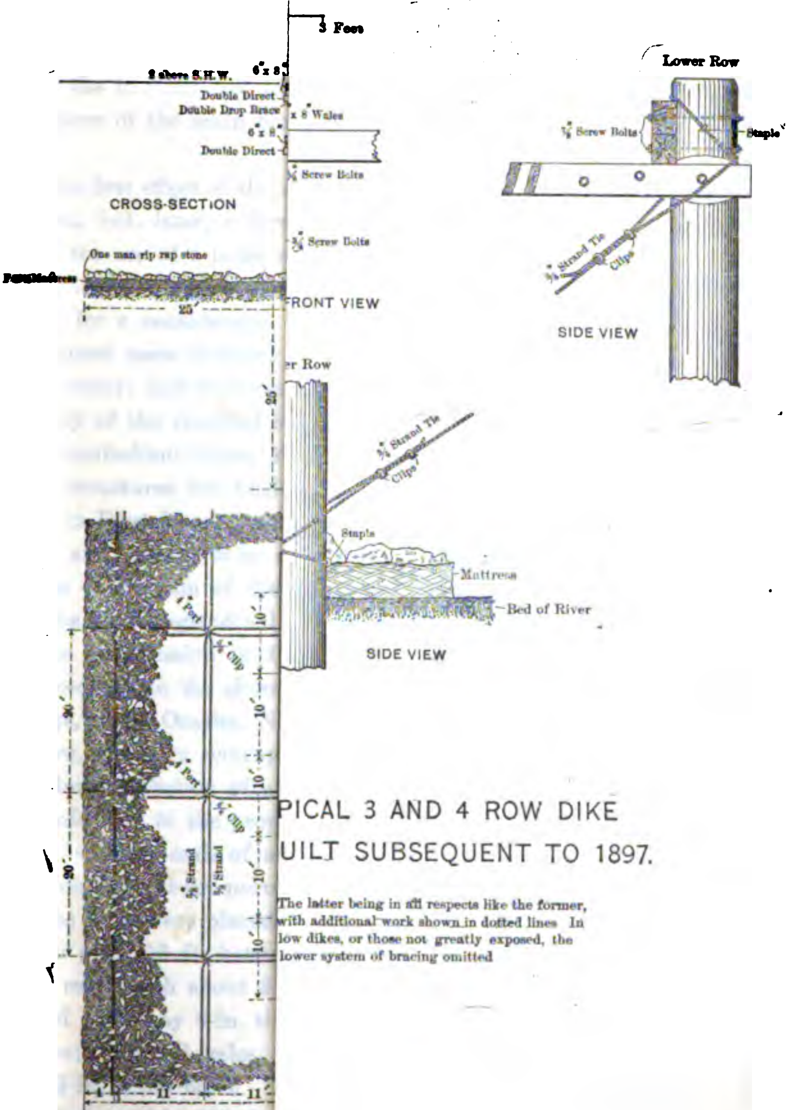
It was expected that the effect of the wide low berm in the structure would be to correct in a large measure the trenching effect of the flow past the dike, but, owing partly to the curtailment of the foot-mattress, and principally to the fact that the berm flow was obstructed by drift-wood which found lodgement in the open work of the berm, little benefit was realized from it.

The object in building the 2-row radial dike, near the lower end of the curved head, was to shut off flow along the inner row of piles. It was prompted by the results obtained with the original structure, one of which was a persistent flow in a narrow chute just inside its inner row of piles.

Early in June, after the dike was completed as above, it was subjected to a specially severe attack, and on the 10th of the month thirteen bents of the high work—750 and 735-ft. circles—in the upper half of the curved head, gave way and were destroyed. The berm was not damaged.

In the fall of 1901, the breach in the high work was closed, the structure was reinforced by additional bracing and re-curtained

PLATE X.
PAPERS, AM. SOC. C. E.
JANUARY, 1905.
FOX ON
MISSOURI RIVER IMPROVEMENT.



PICAL 3 AND 4 ROW DIKE
UILT SUBSEQUENT TO 1897.

The latter being in all respects like the former, with additional work shown in dotted lines In low dikes, or those not greatly exposed, the lower system of bracing omitted

throughout; drift-wood was removed from the berm; and, to hasten the closing of the waterway behind the dike, a length of 300 lin. ft. of standard, deep-water abattis was built in one piece, extending from the in-shore end of the radial 2-row pilework to the accreted foreshore of the main bank, on a line parallel with the stem of the dike.

The first effect of the abattis was to cause a general raising of the bottom, but, later, a threatened flanking at the shore end necessitated the use of a large number of fascines.

When last inspected, Dike No. 5 appeared to be intact, but the berm, for a considerable length at its upper end, was covered with a compact mass of heavy drift-wood nearly to the level of standard high water; and there was still a flow through the structure in the locality of the repaired breach.

Longitudinal Dikes, With and Without Stems.—Though none of these structures was built in the stretch of systematically improved river in First Reach, the results obtained by them, elsewhere in the river, are thought to be of such importance and promise as to warrant a description of them here.

The first longitudinal pile dike on the Missouri River was built by the Commission in 1895-96 for the purpose of masking a pronounced bay in the shore line of the left bank above the Interstate Bridge, above Omaha, Neb. As far as completed, it was a marked success, promptly accomplishing and maintaining, without repair or additional attention of any kind, the object for which it was built. It conformed to the proposed line of rectified shore, and connected with the outer ends of a series of cross-dikes built from the main bank on lines about normal to the flow.

The piles were placed in triangular plan, adjacent piles measuring in place 10 ft. between centers, thus forming (longitudinally) three rows, each about 8⅔ ft. between center lines. The piles were capped with 6 by 8-in. timbers of long-leaf yellow pine, drift-bolted thereto; the usual wales, direct braces and drop-braces were attached with ⅞-in. screw-bolts. The foot-mattress was of the woven form, 125 ft. in width, 100 ft. of it being outside of the outside row of piles.

The longitudinal or training dike is 2 600 ft. in length, and, at its up-stream end, is connected with the main bank by a cross-dike.

Owing to deep water on the line of the latter, a woven mattress, suspended to the piles, was used instead of the usual pole curtain.

The longitudinal dike, for a length of 750 ft. from its up-stream end, and in addition to the usual sill or foot-mattress, was provided with a woven mattress, one edge of which was suspended to the piles and the other edge woven into the sill mattress, so that, in position, it formed a slope in front of the dike. It was expected that the space underneath the suspended mattress would be filled by deposit, thus forming a revetted sub-bank.

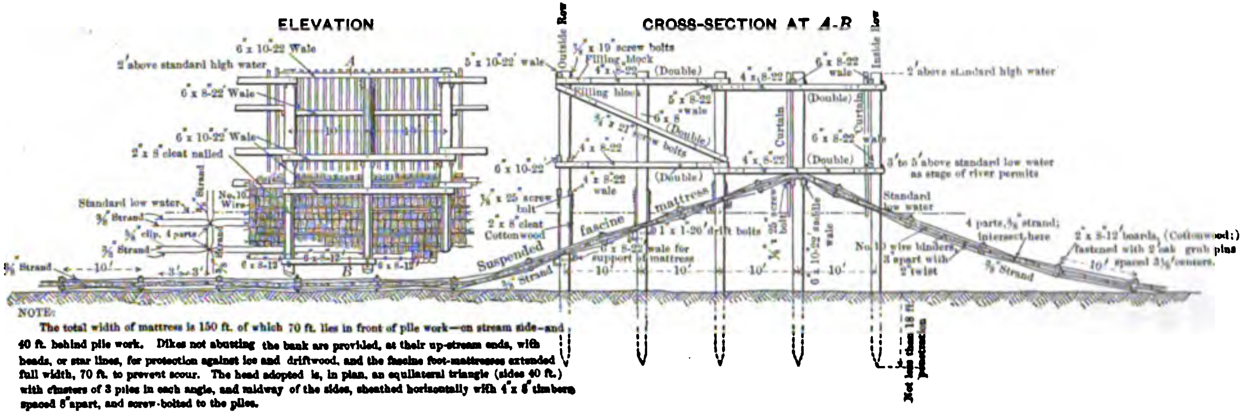
During the fiscal year of 1901, four longitudinal dikes of new design, as shown in Fig. 5, were built: one each in the vicinities of Nebraska City and St. Joseph, one in Wilhoite Bend, above Glasgow, and one in Howard Bend, above St. Charles.

The first two abutted the bank; the other two were connected with the bank by a single stem or cross-dike, also of new design, run out normal to the flow. See Fig. 2, Plate VII.

The design for these dikes, which was closely followed in the essential features, provides for a 5-row pile structure, built to a level grade 2 ft. above standard high water. The piles are spaced at 10-ft. centers in the rows, and the rows are 10 ft. between center lines. The system of bracing is practically the same as that adopted for standard double-system bracing on cross-dikes, except that: strand ties are omitted; the wales on the first or stream row of piles are 8 by 10 in., instead of 6 by 8 in., and an additional wale is attached below the lower system of bracing; smaller reinforcing wales are attached immediately back of the lower two wales, on the down-stream side of the pile; wales on the second row of piles are omitted, except a single string of 6 by 8-in. midway of the upper and lower system; double, direct drop-braces from the upper system on the first row to the lower system on the third row are used.

The distinctive feature of the design is the suspended foot-mattress, with unusually wide fascine. It has a total width of 150 ft., 70 ft. of it being in front of, or on the stream side of the structure. Facine mattress was adopted because, though more expensive than the ordinary woven mattress as usually made, it offered better protection against scour through it, and greater strength. It is formed of compact willow brush fascines, about 8 in. in diameter, and of length equal to the width of the mattress—150 ft. The

LONGITUDINAL DIKES
AS CONSTRUCTED IN 1900 AND 1901
ON MISSOURI RIVER.



NOTE:

The total width of mattress is 150 ft. of which 70 ft. lies in front of pile work—on stream side—and 40 ft. behind pile work. Dikes not abutting the bank are provided, at their up-stream ends, with heads, or star lines, for protection against ice and driftwood, and the fascine foot-mattresses extended full width, 70 ft. to prevent scour. The head adopted is, in plan, an equilateral triangle (sides 40 ft.) with clusters of 3 piles in each angle, and midway of the sides, sheathed horizontally with 4" x 8" timbers spaced 8" apart, and screw-bolted to the piles.

FIG. 5.

fascines are bound and attached to each other, at intervals of 3 ft., by two continuous No. 10 galvanized wires, the latter being brought together between the fascines and twisted for a length of about 2 in. In this way, the wires were locked so that they would not render in the event of rupture, and an opening in the mattress was provided through which, it was thought, sufficient flow would pass to insure the desired fill under the mattress. The mattress is strengthened, longitudinally and transversely, by ⅜-in. galvanized wire strands at top and bottom. These are put on taut, and fastened together at all intersections by cable clips embracing all four strands. The transverse strands are 10 ft. apart, and pass through the pile-work on the up-stream side of the piles. There are thirteen longitudinals, spaced as follows: 1, 10, 30, 50 and 60 ft., respectively, from the outer, or stream, edge of the mattress; on the in-shore side of the first, second and third rows of piles; on each side of the fourth or saddle row; on the stream side of the fifth row; and 20 ft. and 4 ft., respectively, from the inner edge of the mattress. To give the mattress additional longitudinal strength, and to hold the fascines together after the wires and wire strands have rusted out, lines of top- and bottom- board binders, spaced 10 ft. apart, are provided. These are 2 by 8-in. rough, cottonwood boards, 12 ft. long, fastened to each other through the mattress at intervals of 3½ ft. by 2-in. oak pins and wedges.

The mattress is supported at the fourth row of piles on two 6 by 10-in. wales which embrace and are screw-bolted to the piles. At the third, second and first rows, it rests on 6 by 8-in. wales, which are supported by 1-in. square, iron-elbow, drift-bolts. As these bolts are to be submerged, they are driven into the piles at that stage of the driving of the latter when the designated point on the pile has arrived at the bottom of the leads; the pile is then driven to grade. The 6 by 8-in. supports are forced on the elbow-bolts and held there, pending the construction and sinking of the foot-mattress, by board cleats, nailed above water to the piles. The two 6 by 10-in. saddle wales—on the fourth row—are placed so that the surface of the mattress over them will be at an elevation from 3 to 5 ft. above standard low water, as the stage of river at the time may permit; and the supports at the other rows are placed on a grade sloping 1 on 3½ from the saddle wales.

The specifications provide that rip-rap, about 1 ton per lin. ft., shall be used to sink the mattress, the major portion being thrown on and near the outer edge, reserving for the supported portion of the mattress only enough to overcome, with some margin, its buoyant effort. As the mattress inshore from the fourth row serves principally to catch overpour, it is allowed to assume a natural position, with little or no ballast.

The usual pole curtains, with somewhat wider spacing than for cross-dikes, are attached to the fourth and fifth rows. It was expected that the space under the suspended mattress would be quickly filled by deposit, thus giving in effect a revetted and, therefore, permanent sub-bank with stable slope; and the upper bank would be advanced, by deposit after one or more floods, through the agency of the curtains, out to the line of the dike. It would only be necessary then to pave and spawl the upper bank, as provided for in standard bank revetment work, to have a new fixed bank of desired height, location and alignment; and that part of the dike above water could be removed, if desired.

Dike-heads.—Longitudinal dikes which do not abut the bank are provided with heads, or starlings, at the up-stream ends, for protection against ice and drift-wood; and the foot-mattress is extended to full width, 70 ft., to prevent scour. In plan, the head adopted is an equilateral triangle with 40-ft. sides, with clusters of three piles in each angle and midway of the sides, sheathed horizontally with 4 by 8-in. timbers spaced 8 in. apart and screw-bolted to the piles.

Stem-dikes.—The adopted design of stem-dike for connecting such structures to the bank contemplated a 3-row pile structure, with 10-ft. spacing, built to the same grade as the longitudinal dike, and on a line about normal to the flow.

The foot-mattress is of the fascine form—the same as used for standard longitudinal dikes—board binders being omitted. It is 90 ft. in width, 40 ft. of it being on the up-stream side of the pile-work and 30 ft. below the lower row of piles. The mattress is suspended from the middle row of piles on two 6 by 10-in. continuous wales which embrace and are screw-bolted to the piles at the same elevation as those in the longitudinal dike.

The usual wales, and double, direct braces with filling blocks, are attached at the tops of the piles; double, direct braces extend from the upper to the middle row of piles, at the same elevation as the saddle wales; and a string of wales is attached to the upper row of piles immediately above the latter direct braces.

A strand-tie, ¾ in. in diameter, is attached to each bent, from the top of the pile in the third row to the pile in the first row at the bottom direct brace.

The original design provided the usual pole curtain on the middle row, the lower ends of the poles terminating 2 or 3 ft. below the saddle rows.

While the results obtained with longitudinal dikes of the form just described have been satisfactory, as far as their effects upon the conditions of flow are concerned, their cost is so great that it is not probable they will be used in that form, except perhaps to a limited extent in special cases.

The results from the stem-dikes were also satisfactory. It was found necessary, however, on account of scour through the foot-mattress, to extend the curtain on the middle row to the bottom of the river, and to attach another similar curtain to the lower row. It was also found that a foot-mattress 40 ft. wide above a stem-dike is not sufficient. The up-stream edge of the foot-mattress of the stem-dike in Howard's Bend, when in position on the bottom, some 20 ft. below standard low water, was only 22 ft. above the upper row of piles, and the structure was in imminent danger of loss due to scour, or overturning. The width of mattress on the surface should vary with the depth, so that, when sunk in place on the bottom, its up-stream edge would be not less than 50 ft. above the dike. For 25 ft. below the up-stream edge, the mattress should be made as tight as possible, to avoid scour through it; and beyond that it should be opened, somewhat, to permit flow, which will favor deposit under the mattress.

Sheer-dike.—A sheer-dike was built above the dikes in Howard's Bend, on the line of the middle row of the longitudinal dike produced, and extending up stream from the starling or dike-head to the main bank. It was composed of nine clusters of four piles each, driven to a level grade, 5 ft. above standard low water, and spaced 25 ft. apart, between centers of clusters. The clusters were served at their tops with ⅜-in. strand, embracing all the piles in the cluster.

The object in view was the protection of the foot-mattress of the stem-dike from ice and drift-wood, and, incidentally, to take up some of the head, pending the formation of deposits under the mattress.

Pile Sinking.—Prior to 1892 pile sinking on the Missouri River was done almost exclusively by the hydraulic jet. Thereafter, Nasmyth steam hammers, of Cram and Vulcan patterns, sizes B and No. 2, respectively, were used more and more frequently, to the final exclusion of the jet apparatus, after several seasons' work.

From the first crude outfits, consisting of a single set of pile-leads mounted on a small boat, with a hand force-pump for jet supply, more elaborate plants were developed, resulting, finally, in the use of two hulls, one 19 by 76 ft., called the pump-boat, the other 19 by 48 ft. called the cross-boat.

The pump-boat was provided with a steam pump, having a capacity of about 250 gal. per min., for jet supply; a boiler and accessories, and two steam capstans. A cabin covered all except the capstans, and provided sleeping quarters for the crew.

The cross-boat was provided with six sets of pile leads—three sets on each side, spaced at 10-ft. centers—built in the form of a tower, 48 ft. high, and having three working platforms, 15, 30 and 40 ft., respectively, above deck. A steam hoist and steam capstan, also, were on the cross-boat. The former was used in raising the piling and jet-piping attachments into position, and in pulling down on the pile while sinking; the capstan was used to adjust the boat in position. Steam for operating the machinery on the cross-boat was furnished from the boiler on the pump-boat through "gooseneck" pipe connections. The water for the jet supply was carried from the pump-boat to the cross-boat through a 4-in. rubber hose, then along deck to near the center of the base of the tower, in 4-in. iron piping, and thence vertically to the second working platform, where the size of the piping was reduced to 2½ in. and it was connected with a rubber hose of that size, in the axis of a compensating hose reel. The latter was arranged with variable counterweights so that only the necessary length of hose required to reach from the reel to the jet-pipe on the pile was off the reel at any time; and when the jet-pipe was removed from the pile after sinking, the hose was rewound upon the reel automatically. A valve at the pump released the pressure when in excess of 100 lb.

In operating, the two boats were fastened together firmly, the cross-boat lying at right angle to the pump-boat at the pump end of the latter; so that, when in position for working, the pump-boat was on the line of the up-stream side of the upper row of piles in a dike, and the three sets of leads on the upper gunwale of the cross-boat were on the center lines of the upper, middle and lower rows of piles.

Exhaustive experiments were made with nozzles of various forms and sizes, applied in many different ways at and near the base of the pile; and, except in bed formations of gravel or indurated clays, the results, in the main, were satisfactory.

With a jet, it is impossible to sink piles beyond a limited depth in gravel, the return flow being dissipated through it. The prevalence of gravel in the lower valley led to a trial of steam hammers, and they proved to be so much more reliable and efficient, in every way and under all conditions, that, as above stated, they finally superseded the jet sinkers.

In the steam-hammer outfit, the cross-boat was dispensed with; and the hammer operated in a set of special leads, 45 to 52 ft. in height, mounted on the pump end of the pump-boat. The steam pump was replaced with a steam drum-hoist.

In operation, the driver was generally kept head on, to the current, though, when necessary, it could be placed across the current, as the hull was side-raked. Ordinarily, driving progressed from the shore out, each bent being driven complete before removing to the next one. A 100-ft. barge, carrying the supply of piling, was kept alongside the driver on the inshore side and moored to the piles; it served to steady the driver in adjustments for position, as well as during the operation of driving.

The crew of the steam hammer outfit was composed of a foreman at from $60 to $70 per month, a steam engineer at $90 per month, a fireman at $35 per month, and six laborers at $1.10 per day. All were subsisted by the Government. The total daily expense of the driver, including labor, subsistence, fuel and engineer's supplies, was about $20. The average day's work—one day with another throughout say a month—was about 20 piles, driven to a penetration of 25 ft. With all conditions favorable—a skilled crew, medium depth and current, a bed of sand, absence of wind, ample supply of

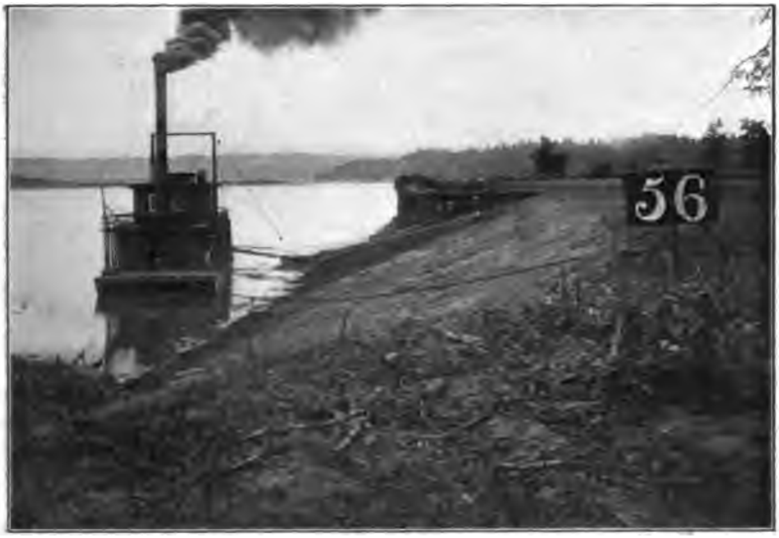


FIG. 1.—HYDRAULIC GRADER AND PARTY, GRADING BANK FOR REVETMENT.

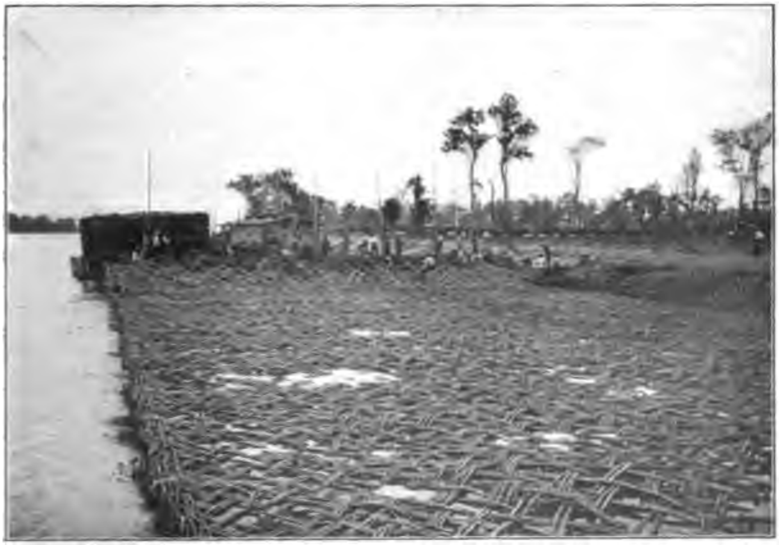


FIG. 2.—PARTY AT WORK, WEAVING MATTRESS.

piling of proper lengths, straight work and no breakage, 80 piles per day have been driven.

For land driving, the leads and hoist were taken ashore on skids and rollers, or, on a frame with two axles and grooved wheels, the latter running on 8 or 10-in. iron piping. Steam was piped ashore from the boat's boiler.

STANDARD REVETMENT.

In a previous part of this paper the various forms of revetment used during the several stages in the development of what has been adopted and is now known as standard revetment were described. The following is a description of the latter:

The natural sequence in which the several branches of revetment construction are carried on is: Bank grading, mattress weaving and anchoring, sinking and ballasting mattress, spawling inshore edge of mattress, paving upper bank, and covering pavement with spawls.

Bank Grading.—The upper bank is graded, between the water surface existing at the time and the 2-ft. contour above standard high water, to a slope varying from 1 on 2 to 1 on 3½, or, flatter in special cases, depending upon the character of the material composing the bank and the attack to which it is exposed. The grading is done with a hydraulic jet. As far as practicable, the irregularities in bank lines are faired out in grading; prominent points are cut back, leaving a low, flat berm from which the slope to the top of the grade is about an average one. In former practice, such points were graded to a uniform slope, flatter than the average. Care is taken that the graded slope shall be smooth and free from ruts or gulleys, and it is of great importance, also, that it shall, throughout, be of material *in situ, i. e.,* no part of the slope above water should be formed of tailings. The settlement of tailings leaves a shoulder in the bank which, unnoticed or not properly treated, invites destruction of the upper bank work. Partly on this account, the best revetment can be constructed when the stage of river is lowest; and all revetments built at a stage of 5 ft. or more above standard low water should be inspected at a lower stage, with a view of discovering and treating shoulders in the bank which are more than 3 ft. above standard low water.

Grading Outfit.—The hydraulic grading outfit, as most recently provided, consists of: A grading boat, Fig. 1, Plate XI, having a hull 20 by 80 ft., on which there is a compound, condensing steam pump, of the packed-plunger pattern, having a capacity of about 600 gal. per min. at a piston speed of 100 ft. per min.; a steam capstan at the pump end of the boat, for use in moving the boat and for light snag pulling or grubbing; a hand capstan at the other end of the boat; and a boiler for steam supply. The pump and boiler are inclosed with a cabin which provides sleeping quarters for the crew. A mast at each corner of the pump end of the cabin is used to operate a boom in which the discharge hose is carried ashore on either bank.

The water supply for the pump comes through a screened suction pipe in a screened well within the hull. The discharge is carried in 6-in. iron pipe from the pump to both gunwales, at the foot of the masts, for use on either bank of the river, the one not in use being capped. From the boat to the play-pipe, ashore, the water is conducted in 4-in. rubber hose, a length of 75 ft. being required under ordinary conditions. The play-pipe at the shore end of the hose is of copper, 4 ft. in length, and tapers from 4 in. in diameter at the hose to 2 in. at the nozzle end. It is operated by a wooden lever, about 8 ft. long, to which it is fitted and strapped. The lever is held against recoil, and is given full movement in all directions by means of a gimbal, which sets, at an elevation of 16 to 20 in. above grade, in a 2-in. gas pipe driven firmly into the earth. The jet is played upon the bank at close range, the loss of time involved in the necessary resettings being repaid by the greater efficiency of the jet. The form of nozzle tip which gives the best results—the most compact, solid jet—is cylindrical for 2½ diameters of the orifice back from the orifice, and thence, to the play-pipe connection, conical. The cylindrical surface of the tip should be kept highly polished. With the pump working at full capacity, and an average bank, a jet 1¼ in. in diameter gives the best results.

A grading crew consists of a steam engineer at $90, a fireman at $35, a nozzleman at $50, and two laborers at $35 each per month; all with subsistence. The total daily expense for labor, subsistence, fuel and engineer's supplies is about $15. In a day's work, from

500 to 1 800 cu. yd. of earth are removed, the amount depending upon the character of the bank and the slope to which it is graded.

Mattress Weaving and Anchoring.—The mattress is of a continuous, woven-willow construction, extending from the 3-ft. contour above standard low water on the graded slope, or, from the water's edge if the stage be above that contour, to 80 ft. beyond the standard low-water contour, thus providing for a mimimum width of mattress of about 86 ft. It is compactly woven to a thickness of not less than 12 in. or more than 18 in., according to the size of the brush or according to the exposure. Dense thicket-grown willows, which average about 1½ in. at the butt ends, are best adapted to the work, with smaller brush—from ½ to ¾-in. for weaving a selvage on the shore and stream edges of the mattress. Brush having a larger butt diameter than 2½ in. should not be used, and if much of the brush is greater than 1½ in. in diameter, enough small brush should be used with it to give the requisite compactness. The strength of a woven mattress is no greater than the frictional resistance to motion of the composing brush. To give additional strength, required to meet the severe strains imposed while the mattress is being sunk, as well as in subsequent movements or adjustments to scour, and, for the purpose of anchoring the mattress to the top of the bank so that it will not, under any conditions, slip or slide, a system of ⅜-in. galvanized-wire strands, running lengthwise and crosswise of the mattress, is used. Both longitudinal and transverse members are composed of two ⅜-in. strands each; one of which lies wholly underneath and the other wholly on top of the mattress—one part immediately under the other. There are six continuous longitudinal members, laid parallel, and spaced as follows, measuring from the outer selvage edge inshore: 6, 16, 31, 46, 66, and 85 ft., the last one being in the inner selvage edge. All these longitudinal members are paid out under tension, as the mattress is made, from reels on the mattress-boat, the top strand of each longitudinal passing through a fair-leader suspended some 18 ft. above the brush platform.

There are six transverse members (of two ⅜-in. strands each) to every 100 lin. ft. of mattress, extending, one strand on top of the mattress and the other directly underneath it, from the outer selvage edge to deadmen on top of the bank, back of the graded slope.

They are laid about normal to the midwidth line of the mattress, so that, if the latter be a straight line, the transverse members will lie parallel to each other across the width of the mattress and 16⅔ ft. apart, or, if curved, approximately on radial lines 16⅔ ft. apart at midwidth of the mattress. This is readily accomplished, as the mattress-boat advances down stream with the weaving, on lines normal to the midwidth line; and the transversals are run out from a reel on shore, the bottom part first, enough strand being pulled through, past the outer selvage of the mattress, to reach ashore when laid back on top of the mattress and thus form a complete transverse member with a bight at the outer selvage. Both parts of the transversals are laid, just after the weavers pass the line, so that they are not woven into the body of the mattress. At all points of intersection of transversals with longitudinals, the four parts of strand are brought together and fastened by stirrup-bolts or clips of 7/16-in. iron; but, before the fastenings are made tight, both parts of the transversals are put under tension, from the outer selvage edge to deadmen ashore, by means of blocks and tackle. The deadmen are either rough blocks of stone, containing from 2½ to 3½ cu. ft. or, pile butts 12 in. or more in diameter and 4 ft. long. The stone blocks should be not less than 10 in. thick. Pile butts of upland-grown white oak are preferred, but long-leaf yellow pine is used extensively. The deadmen or anchors are planted 8 ft. back of the top of the graded slope, and from 3 to 5 ft. deep, according to the character of the ground. From the top of the slope to the deadman in place, the strands lie in a narrow trench dug for that purpose.

As above stated, the weaving and, indeed, all branches of the work progress down stream. The start is sometimes made with the mattress-boat lying face on to the bank, and a quarter circle of mattress is woven, the lower inside corner of the boat being held against the bank while the upper end of it swings out, as the mattress is woven, to a position normal to the bank. The usual method, however, is to start the mattress of the full width at the up-stream end of the graded slope, the upper edge being stiffened, against buckling, by a bolster, or fascine of brush, extending the full width of the mattress, and into which the weaving is meshed. In both methods the longitudinals are carried ashore on converging lines, leading well up stream to a substantial anchorage.

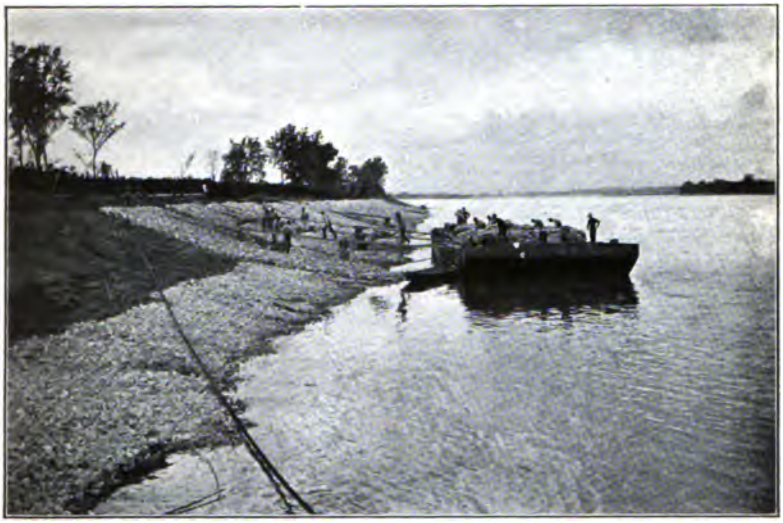


FIG. 1.—BANK REVETMENT. PARTY PAVING UPPER BANK.

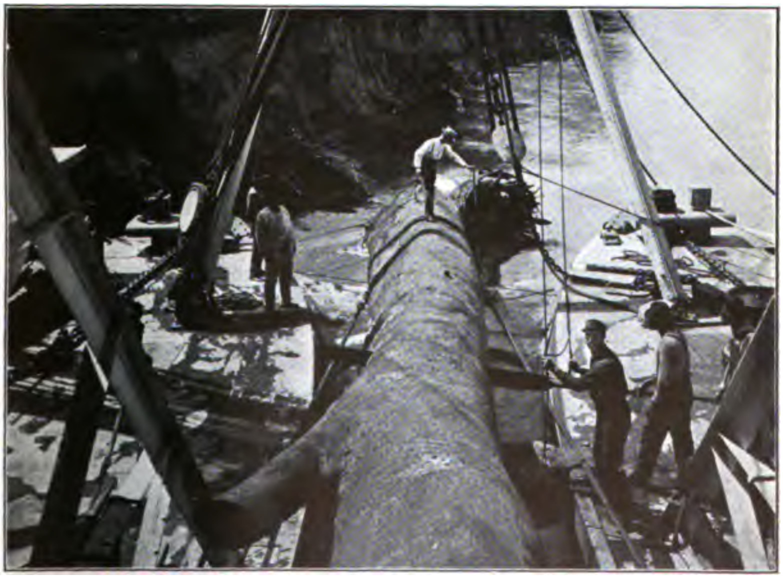


FIG. 2.—U. S. SNAG-BOAT "C. R. SUTER," REMOVING SNAGS.

The boat upon which the mattress is made may be any decked hull of such length as will afford a flat working space of from 8 to 10 ft. at its outer end, and, with a short outrigger if necessary, a sloping deck from 10 to 15 ft. wide and as long as the width of the mattress. The weaving platform should slope about 1 on 3½, and be provided with launching ways of 3 by 8-in. stuff, spaced from 6 to 10 ft. apart between centers. In the rear of the launching ways and on a level with their top ends, a platform, 10 ft. wide, or more, should extend the full length of the boat. The brush for weaving is brought in wire-bound bundles and laid crosswise—butts up stream—on this platform. The bundles are then opened and the brush is passed, one or more pieces at a time, to the weavers. The brush platform may be on a separate hull lashed to the lower side of the weaving boat. The wire strand is on reels mounted under the brush platform. Upright scantlings extend 20 ft. above the platform, for the support of the top longitudinal strands.

A crank capstan at each end of the mattress-boat serves to pull the boat down stream as the weaving progresses, the head lines, meanwhile, being slackened.

Specially designed mattress-boats, 25 by 70 ft., adapted for dike work as well as revetments, are self-contained. The lower gunwale is high; the upper one, low and raked for easement of dynamic head of flow, is flush at its shear line with the way floor; the latter is caulked, and rises on a slope of 1 on 3½, giving a working surface 13½ by 66 ft. (for revetment work 10 ft. of additional floor space is given at either end, as required, by detachable outriggers); the brush platform is 12 by 66 ft., its lower edge being flush with the plane of the lower gunwale; it is supported along the lower edge and on a line 8 ft. inboard by stanchions. The boat is stiffened by a longitudinal truss.

A weaving and anchoring force is composed of a foreman at $60 per month, 11 weavers at 16⅞ cents per hour, and 30 laborers at 13¾ cents per hour; all with subsistence. Fig. 2, Plate XI, is a photograph of a party weaving a mattress.

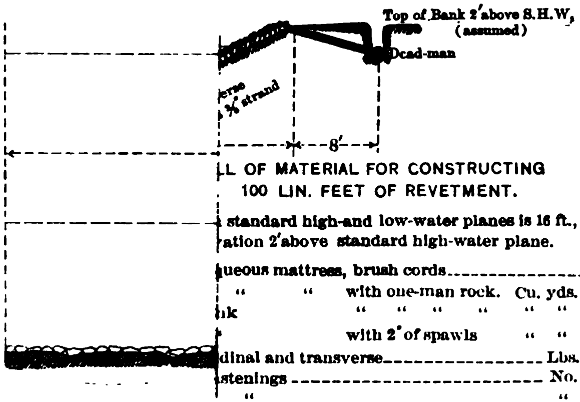
An average day's work is 100 lin. ft. of mattress, so that the average cost for labor and subsistence is between 65 and 70 cents per linear foot.

Sinking and Ballasting Mattress.—Specifications for standard revetment provide, that ¾ cu. yd. of rip-rap per lin. ft. of mattress shall be used in sinking it to close contact with the bottom, the distribution being such that the weight per square foot of mattress increases from the shore out. It is also specified that, in addition, 50 cu. yd. of stone shall be placed on 50 lin. ft. of mattress at the head, and 1 cu. yd. per lin. ft. on all laps. The stone is thrown from a barge, which is dropped down stream over the mattress, with its outer end somewhat in advance of the shore end. As the work is laid off in sections of 100 lin. ft., and the contents of the barge are known, the quantity of stone placed on each section is readily ascertained. It seldom happens that the full complement of stone is placed in sinking, a sudden shifting of the barge being often necessary to prevent buckling, especially in a swift current; it is usual, therefore, to go over it a second time. The sinking is not carried closer than from 150 to 200 ft. above the mattress-boat, and as much as 1 000 lin. ft., or even more, of mattress is sometimes made before sinking is commenced. There is danger in having so much mattress afloat, however, as a sudden rise may occur, and, though it might not otherwise damage the work, it would possibly foul the mattress with drift-wood so as to impair its efficiency seriously.

Spawling In-Shore Edge of Mattress.—This operation, which follows sinking and precedes paving, consists in filling well the interstices of the mattress, from its in-shore edge to the contour 3 ft. below standard low water, with small spawls or quarry chips; and, fairing up, with the same material, the shoulder formed by the edge of the mattress where it lies on the graded slope. The former is done to stop wave action through the mattress and to solidify the mattress against ice in the event of the removal of the paving or ballast; the latter to give a fair surface for the pavement, and to check wash from surface drainage. About 0.1 cu. yd. of spawls per lin. ft. is required.

Paving and Spawling Upper Bank.—The upper bank, from the contour 2 ft. above standard high water to standard low water, and as much lower as the existing stage of river permits, is covered with a paving of rip-rap, 12 in. thick at standard low-water contour and 12, 8 and 6 in. thick, respectively, at the top of 1 on 2, 1 on 2½ and 1 on 3 slopes. A 2-in. covering of spawls or fine quarry chips is put on the paving, thus completing the revetment. The paving is

PLATE XIII.
PAPERS, AM. SOC. C. E.
JANUARY, 1905.
FOX ON
MISSOURI RIVER IMPROVEMENT.

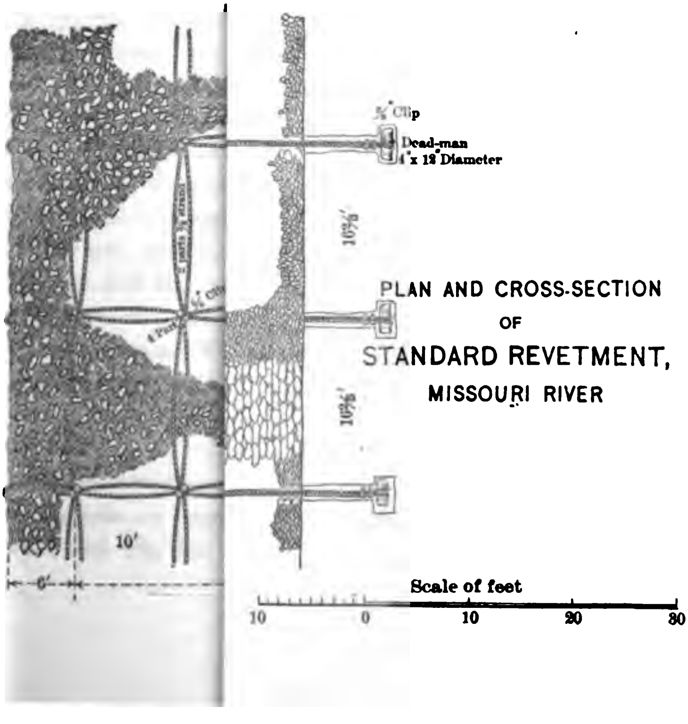


LL OF MATERIAL FOR CONSTRUCTING
100 LIN. FEET OF REVETMENT.

standard high-and low-water planes is 16 ft., and paving ation 2' above standard high-water plane.

ueous mattress, brush cords		00
" " with one-man rock.	Cu. yds.	75
nk " " " "	" "	150
with 2" of spawls	" "	24
dinal and transverse	Lbs.	790
stenings	No.	42
"	"	12
eads 4 x 12 diam. long-leaf yellow pine or white		
cks, 32" x 12" x 12"		No. 6

f stone on upper bank varies with height between nd low-water planes, the height of bank; the stage at ne, and with the grade of the slope, the paving being ard low-water and 12," 8" and 16" thick, respectively, at on 2½ and 1 on 3 slopes, with 2" of spawls on top.



PLAN AND CROSS-SECTION
OF
STANDARD REVETMENT,
MISSOURI RIVER

done from the top of the slope down, the stones being set up edgewise and placed with some care to make a compact covering, so that when completed ready for the spawls it presents the appearance of a reverse shingling. In this form it is well adapted to resist wave action, and dislodgment by ice, drift-wood or other forces to which it is likely to be exposed. The spawls, thrown on at and near the top of the slope, are raked down over the pavement, and, after filling the interstices, find lodgment in the series of steps in the paving surface.

As will be seen from the foregoing, the quantity of rip-rap for paving, as well as the spawls required per linear foot of bank will vary with the height between the planes of standard high and low water, the height of the bank when lower than 2 ft. above standard high water, the stage at which the work is done, and, to some extent, with the grade of the slope; but the paving stone will average about 1½ cu. yd. per lin. ft., and the spawl covering will be less than ½ cu. yd. for a height of 16 ft. between the high- and low- water planes. Fig. 1, Plate XII, is a photograph of a party at work paving the upper bank; and Plate XIII is a plan and cross-section of the standard revetment.

Cost of Works on the Missouri River.—The cost of standard pile-dikes and revetments necessarily varies so widely that unit costs cannot be stated definitely. The following are the principal elements which enter the question of cost:

Difference in elevation of high- and low- water planes; height of bank; distance of work from base of supplies; plant charges; extent, and degree of concentration, of work; season of the year in which carried on; and conditions of flow. For preliminary estimates, however, $10 per lin. ft. of cross-dike or revetment and $35 and $20, respectively, per lin. ft. of 5-row longitudinal and 3-row stem-dikes, as described herein, may be used to cover all items.

In carrying on numerous works at widely separated localities, it was found that the field charges against the allotment were distributed as follows:

For actual construction 67%; for care, repair and moving plant 22% (this includes an item of only 5% for light repairs); administration 9%; and 2% for all other items, including surveys and travel.

SNAGGING.

Under general appropriations for the removal of snags from Western rivers by the General Government, beginning about 1856, ceasing during the Civil War, and continuing intermittently thereafter, the Missouri River, the "Snaggiest" of all streams, received its modicum of work for the avoidance of danger to its navigation from this cause.

The necessity for such work on the Missouri River is made apparent by the statement that the wrecks of some 300 steamboats now lie embedded in its sand. Of these wrecks, 195 were caused by snags and 11 by rocks.

The boats used in the removal of snags and other obstructions were crude and inefficient, in their earliest forms, but were developed into model machines for the work they had to perform. The hulls had been built of wood, and were of the catamaran type, up to 1874, when the first contract for iron construction, with a single hull and a forked bow, was entered into.

The *J. N. Macomb* (1874), the *H. G. Wright* (1880) and the *C. R. Suter* (1888), the latter two being steel, are still in service and highly efficient.

The dimensions of the largest boats are: Length 187 ft., beam 62 ft., and depth of hold 8 ft. Their draft is about 4 ft. The *C. R. Suter,* especially designed for the Missouri River, is 187 ft. long, 52 ft. beam, and 7 ft. hold, with a draft of 3 ft. Their present valuation is from $100 000 to $120 000 each.

These boats were built from designs by Colonel Charles R. Suter, M. Am. Soc. C. E., who was in charge of the river from 1874 to 1896, during the latter portion of the period—1884 to 1896—being President of the Missouri River Commission. To that able officer and to his able successor, Colonel Amos Stickney, is due the credit for much that is of scientific interest and value in our present knowledge of the physics of detrital rivers and methods for their control.

From March, 1889, when placed in commission, to June, 1902, the *C. R. Suter* destroyed 17 767 snags, removed 69 wrack-heaps, felled 6 076 trees likely to become snags, and traversed 18 108 miles of river. The total amount expended in the operations of the boat, including repairs, etc., was about $380 000.

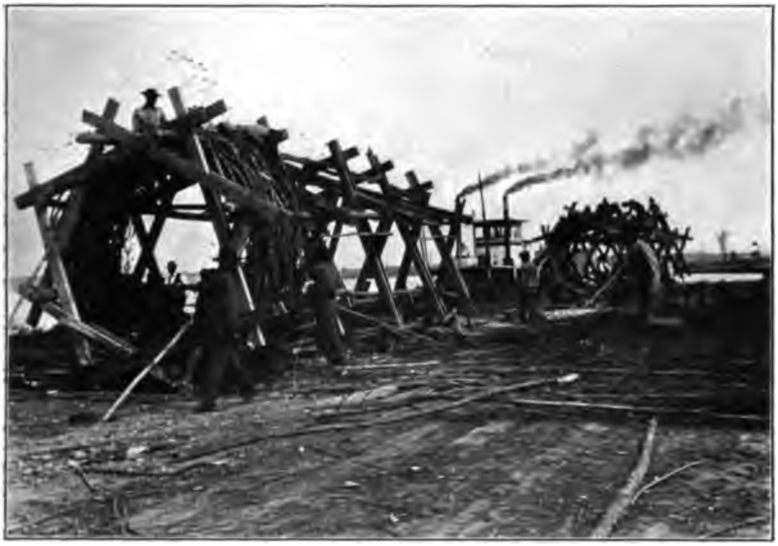


FIG. 1.—A GABION, IN PROCESS OF CONSTRUCTION.

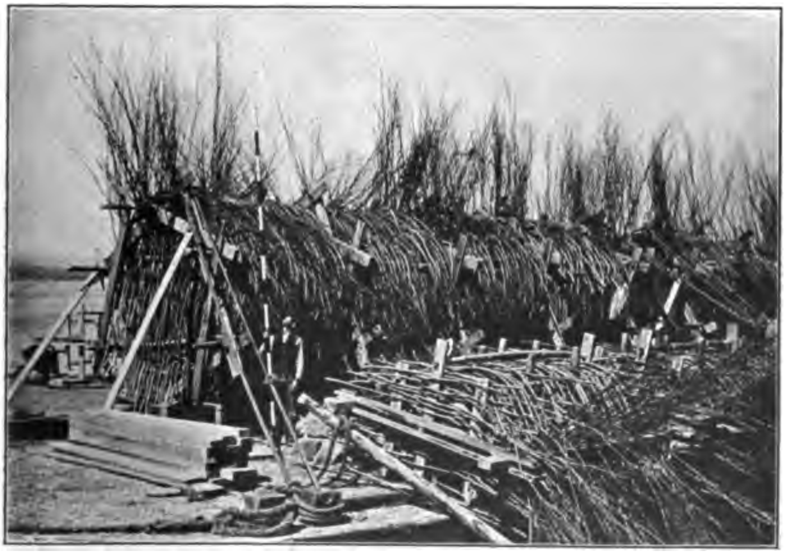


FIG. 2.—GABIONS AND BURRS, READY FOR USE.

Fig. 2, Plate XII, is a view of the *C. R. Suter* removing a large snag.

Fig. 1, Plate XIV, is a photograph of a gabion, in process of construction. Gabions are made of various sizes, from 8 to 12 ft. in diameter, and of any length up to 30 ft. They are used in building submerged groynes at bank-heads.

Fig. 2, Plate XIV, is a photograph of some gabions and burrs ready for use.

Vol. XXXI. JANUARY, 1905. No. 1.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PAPERS AND DISCUSSIONS.

This Society is not responsible, as a body, for the facts and opinions advanced in any of its publications.

THE RECLAMATION OF RIVER DELTAS AND SALT MARSHES.

Discusssion.*

By E. L. Corthell, M. Am. Soc. C. E.

Mr. Corthell. E. L. Corthell, M. Am. Soc. C. E. (by letter).—This paper is upon a subject which is not often brought before the Society, and yet it is a most interesting one. The general and detailed features have been covered very completely and ably by the author, and the paper will constitute a valuable source of reference for the members of the Society when considering at any time the subject treated. The writer desires only to give some additional information from his own experiences and study of the data upon the "Location and Character of the Lands of the Mississippi Delta." This feature of the subject is worthy of a paper of considerable length, but in this discussion only a general *résumé,* with some interesting facts, can be given.

The area under consideration, and a much more extensive area, is practically a new country, certainly a new country geologically speaking, for it was made long after the geologic age and even within the life of man upon this earth, for it is hardly more than 1 000 years old.

In connection with the work at the mouth of the Mississippi River and the project for a bridge over that river immediately above

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* This discussion (of the paper by J. Francis Le Baron, M. Am. Soc. C. E., printed in *Proceedings* for November, 1904), is printed in *Proceedings* in order that the views expressed may be brought before all members of the Society for further discussion.

Communications on this subject received prior to February 25th, 1905, will be published subsequently.

New Orleans, certain facts from the borings made by the writer and **Mr. Corthell.** from those made by others, as well as from a general examination of the whole area of the Mississippi Delta, enable us to understand something of the character of the material composing the delta and, perhaps, to arrive approximately at the depth of the same. Enough has been ascertained by borings and other examinations to show that the Mississippi River, in the delta proper, at least in the last 200 miles of its course, does not flow in "a channel belonging to the geologic epoch antecedent to the present," as claimed by a distinguished writer about half a century ago.

While investigating the bed of the river, to a depth of 200 ft. below low water, for the proposed bridge above New Orleans, the writer requested Mr. Frank T. Howard, of New Orleans, who had some years before sunk an artesian well in Lafayette Park in that city, to state what materials were passed through. The following quotations are from his letter:

> "Drift formations, clay, white sand, marl, gray sand, yellow sand, mud, in different layers. Seven hundred and five feet, drift-wood pumped up.
>
> "Seven hundred and forty-two feet, clean, coarse sand and gravel. The gravel became coarser as the drill descended, and rock was expected, but the drill suddenly entered a stratum of clay, broken shells and drift-wood, 69 ft. thick.
>
> "Eight hundred and nineteen feet, fine blue sand, which contained sea-shells, coral and many kinds of fossils..
>
> "Eight hundred and fifty-three feet, clean white sand, salt water; at bottom of this bed large quantities of drift-wood came up, cedar and cypress woods.
>
> "Eight hundred and seventy-nine feet, pipe slipped through large hole about 18 ft., and water was pumped down for half an hour, but none came up.
>
> "Eight hundred and ninety-eight feet, bed of hard clay, 7 ft., under which was a quicksand, hard to penetrate.
>
> "Through 108 ft. more, differeut layers, drift-wood, clay, and shell banks.
>
> "Ten hundred and forty-two feet, *drift-wood.*"

Mr. Howard is of the opinion that that part of Louisiana was once covered by the Gulf of Mexico and that the depth of water was probably 2 000 ft. or more. From some other information it is known that the drill broke, finally, in a cypress log.

At Magnolia, the plantation of Governor Warmouth, 45 miles below New Orleans, a well sunk to 980 ft. showed similar stratifications, though no wood was encountered. From the bottom of the well there came up, with very salt water, an inflammable gas, which, when set on fire, gave a fountain of flame.

Many other wells have been sunk to a depth of 400 ft. or more, all of them showing nothing but alluvium.

Mr. Corthell. The investigations of the Mississippi River Commission, and the observations of many people competent to form a judgment, indicate that before the construction of levees, which prevent the overflow of the river, the annual accretions, deposited upon the older layers of material dropped in preceding years and centuries, brought additional weight upon all the delta lands, and in the lower part of the delta, nearer the Gulf, where no levees exist, this action is still going on. This weight produces a subsidence and compression of the lower strata, but, owing to the fact that the annual accumulation is slightly in excess of the subsidence, the latter action is not noticed, except in the area protected by the levees, where the overflow is prevented.

It was the opinion of the late Major C. W. Howell, M. Am. Soc. C. E., United States Engineer, who was for many years in charge of the improvements at the mouth of the Mississippi, that this annual superimposed weight upon the outer or Gulf slope of the delta caused the formation of mud lumps, which are found at the mouths of some of the passes of the river. The movement appeared in the form of ridges or wrinkles by which sometimes several acres of a sticky clay appeared in a few hours and sometimes rose to a height of 10 or 12 ft. above the water.

In reference to the important subject of the general subsidence of the delta, the writer is personally familiar with the following detail:

Several hundred years ago, the Spaniards built a magazine, of brick masonry plastered with mortar, on Balize Bayou leading out of one of the now unused passes of the river. While the writer was engaged in building the jetties at the mouth of the South Pass, he examined this old structure, which was in a good state of preservation. The exterior was intact, as far as could be seen and examined, there were no cracks in it indicating a settlement, and it was perfectly level, but the surface of the water was across the arch which crowned the entrance door, the sill of which was at least 10 ft. below the water. Twenty years afterward, the writer had this magazine again examined. It had gone down somewhat further, and enough of the roof and arches remained to show that the settlement had been proceeding at about the same rate as for 200 years previous, and averaged about $\frac{1}{20}$ ft. per annum.

Even at the Head of the Passes, where the ground is apparently solid, the same subsidence is going on. At the head of the South Pass, the rails of a railroad track, which had been laid many years before for carrying coal from the barges to the coal pile for the United States Government, were found to be projecting from the bank and 2 or 3 ft. below the surface of the ground, and it may be said that they were relatively below the surface of the water. These

Mr. Corthell.

rails had not sunken into the material, for the ground was hard and solid, but they had evidently gone down with it; and, as this ground went down, the annual deposits from the overflow of the river have kept the surface at about the same level in respect to the level of the water surface.

Twelve miles above the head of the South Pass, or about 24 miles from the mouth of the river, it was found that a telegraph cable, which was put down many years before, and not more than 1 ft. below the surface in a small ditch when laid, was from 5 to 8 ft. below the surface, and drift-wood had to be cut away to reach it. In order to investigate a little further, a willow tree was taken for examination. This tree was about 10 in. in diameter, and was back of the shore near the edge of the swamp. A dam was made about the tree, and an excavation, which finally reached a depth of 8 ft., was dug on one side of it, and the tree showed rows of dead roots all the way down.

Two or three miles above the Head of the Passes, was built, many years ago, a pilot's house, on brick piers 5 ft. high. The ground is now up to the sills of the house, but the surface of the ground bears about the same relation to the water surface in the river as when the house was first built.

Land in the Lower Delta is not only going down, but there are lateral movements which are very interesting. The base line along a solid island at the mouth of the Southwest Pass, lengthened in a few years, by accurate measurements, from 700 to 712 ft.

The writer was employed in 1895 by the estate of the late James B. Eads, M. Am. Soc. C. E., to collect data to present their case before the War Department. The case was briefly the following:

The contract with the Government, made by Congress in 1874, provided for the maintenance for 20 years of the channel to be obtained by the jetties; $100 000 was to be paid quarterly as the estimated cost of maintenance; $1 000 000 was held back as security for the maintenance of this channel, one-half of it to be paid after 10 years, and the other half after the remaining 10 years. This amount was assumed to have been earned, and the interest on it at 5% was to be paid semi-annually. The amount per day in the first 10 years was $410, and $324 during the second decade. The act required:

"The respective depths and widths of channel being measured at the average flood tide, as ascertained and determined by the Secretary of War."

"The average flood tide," as the datum plane, was established from the record of an automatic tide gauge, which ran continuously through three lunations, and read at average flood tide 2.76. It was established at Port Eads. It was not long before a slight

Mr. Corthell discrepancy appeared, the mean of all the high waters of each year gradually reading higher on the gauge as the years went by, until, in 1890, the mean of the year read 4.001 ft. Either the gauge had gone down and all its reference bench-marks, one of which was on the foundation of the light-house not far away, or else the surface of the Gulf had risen progressively from 1875 to 1890. The writer, by correspondence with engineers at various ports on the Gulf, in the United States and in Mexico, ascertained that their tide gauges showed no change in the Gulf level during this period, and, after favorable consideration by the Secretary of War and a discussion of the legal questions, the datum plane was changed to conform to existing conditions.

Without going further into these details of subsidence, it may be stated generally that the question is one of great importance to the whole Delta country; that is, the outlying agricultural districts. There are really no compensating conditions, for the reason that the river, along its lower course in Louisiana, except near its mouth, is fully and safely leveed by the United States Government and the State of Louisiana. The late G. W. R. Bayley, M. Am. Soc. C. E., Mr. Eads' associate, a long-time resident of Louisiana, and engaged in many of its important works, was a very careful observer and an engineer of excellent judgment. He had wide experience with the levees of Louisiana, as well as upon the construction and maintenance of the New Orleans and Mobile Railroad. He was always very pronounced in his opinion that the subsidence of the Gulf lands was going on, and was becoming more and more apparent as the river was becoming more and more leveed.

The subsidence of these lands is not peculiar to the Delta of the Mississippi, but the same action is taking place on all coasts where there are sedimentary deposits, such as Holland, where the rate of subsidence is about $\frac{1}{10}$ in. a year, but the rate of subsidence in Louisiana is considerably greater.

The lands which the author includes in his general discussion of rice lands and other lands, on which formerly the finest sugar cane was raised, are affected by this general subsidence. Many large tracts which were formerly very productive in rice and particularly in sugar, have been abandoned in consequence of the salt water encroaching upon them. The people believed that it was due to the rising of the Gulf waters, but it is really the effect of the sinking of the land. Many of these lands are now completely covered with sea water. Many islands on the Gulf Coast—Caillou, Last Island, and others—which were formerly pleasure resorts for the people of New Orleans, and were well above the water, have been abandoned for some time and are becoming marshes. Even in the interior, north of Lake Ponchartrain, there is proof of altered levels, although the change is less marked than on the coast. Regardless of this subsidence, the richness of the delta land and the practicability of protecting it from overflows of the river and encroachments of the sea, make the subject treated by the author of great importance to the State of Louisiana. With the modern methods of raising rice, and its increasing use, there is no doubt that these delta lands will produce an important and increasing product for the benefit of the entire country. Mr. Corthell.

Vol. XXXI. JANUARY, 1905. No 1.

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PAPERS AND DISCUSSIONS.

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THE STRUCTURAL DESIGN OF BUILDINGS.

Discussion.*

By Messrs. E. W. Stern, Charles G. Darrach, L. J. Johnson,
E. C. Shankland, Foster Crowell, St. John Clarke,
William W. Crehore and C. A. P. Turner.

Mr. Stern. Eugene W. Stern, M. Am. Soc. C. E.—The speaker wishes to add, to those already expressed, his thanks to Mr. Schneider for this timely and valuable paper, and his appreciation of the labor involved in its preparation.

The past decade has seen a vast amount of building construction, in which the Engineer has taken a very prominent part; and wide and free discussion, by those having experience in this class of work, should prove of great benefit to the Profession.

As a whole, the speaker finds very little in Mr. Schneider's paper to criticise, and very much to commend.

The application of concentrated loads to beams, and the author's method of designing foundations for dead load only, is heartily approved; also, the schedule of requirements for steel, which, if generally adopted, would tend to simplify and make uniform the processes in the steel mills.

Mr. Schneider has emphatically condemned the use of cast-iron columns in building construction. In this the speaker must take issue with him. While he does not advocate their use in high buildings, or under any or all circumstances, he still believes that they may often be used profitably in buildings where wind bracing is not necessary; but only under thoroughly competent supervision and inspection. Mr. Stern.

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* Continued from December, 1904, *Proceedings*. See September, 1904, *Proceedings* for paper on this subject by C. C. Schneider, M. Am. Soc. C. E.

The requirements of modern building construction, as well as machine building, have developed a higher state of the art than that which existed years ago when the bridge builder very properly condemned it.

The modern foundry has adopted better methods, and more is known about the proper mixing of iron, and making the moulds, as well as in designing castings. It is possible now, under proper supervision, to obtain satisfactory results, if the work is properly designed. The materials should be of the right proportions, and, in the design, proper consideration should be given to shrinkage. The castings should be properly stripped in cooling, and a sufficient number of test holes bored to determine whether or not the core has shifted.

It is the writer's practice to insist upon the following conditions:

1.—A material which develops a strength of 2 400 lb. central load on a bar 1 by 1 by 12 in. with a minimum deflection of 0.1 in., and which is not so brittle as to break off when struck on an edge with a hammer;

2.—Column brackets or seats in which the metal is never more than ½ in. thicker than the column, preferably of equal thickness or less;

3.—A maximum shear of 1 500 lb. per sq. in. for brackets, and 2 500 lb. in tension.

Mr. Schneider says that "beams are supported by lugs or brackets cast on the columns, thus producing eccentric loading and bending strains."

Eccentric loading, whether in steel or cast columns, must be considered, and the column section must be increased to take care of it. Very often, by properly balancing the loads, and by adjusting the position of beams, eccentricity can be largely reduced.

It would be an extremely difficult matter to legislate cast iron out of use. Would it not be better, therefore, to establish a high standard for its use, and thereby insure good results, than to ignore its existence as a material of construction?

The speaker hopes that Mr. Schneider will see fit to write a specification for cast iron. A specification for structural iron work for buildings is certainly not complete without it.

Paragraph 3, Table 2, Live Load.—While it may be true that the actual weight of all persons who could possibly be assembled in a room with fixed seats would be not more than 40 lb. per sq. ft., still there are occasions when these seats may be removed or decked over so that a greater load could be placed upon the floor. Vibration, Mr Stern. also, should be considered. In view of this, the speaker does not think that 80 lb. per sq. ft. is any too much for public rooms with fixed seats. As regards the loads in assembly rooms, armories, ballrooms, etc., in which there are no fixed seats, it is the speaker's opinion, based upon observation, that a mass of people may weigh 30 lb. per sq. ft., and, considering that in all such places vibration, due to a mass of people moving, may occur, he believes that a load of 120 lb. per sq. ft. would not be too much.

Sidewalks in front of buildings should provide for a live load of at least 300 lb. per sq. ft.

Paragraph 12.—This paragraph appears to the speaker to be ambiguous. In the finished structure, are the walls and the partitions to take any of the wind load, or is the steel frame to take it all? If the latter meaning is intended, the speaker does not agree with Mr. Schneider. The finished walls and partitions of buildings may certainly be very efficient in withstanding wind pressure.

Paragraph 13, Foundation Loads.—The permissible pressure on foundations is, of course, a matter which requires careful consideration of the case in hand, and trained judgment.

In poor soil, a test should always be made. In some cases, where certain kinds of soft clay or fine wet sand are met, the pressure might have to be reduced to ½ ton per sq. ft.

Paragraph 14.—The speaker believes that the use of lime mortar should be prohibited in engineering work, as lime mortar is very uncertain in hardening, and hydraulic cement is so cheap that it hardly pays to use lime. In fact, Portland cement is almost entirely specified by the writer, to the exclusion of even natural cement, as being much more reliable and as costing very little more for the same strength of mortar.

Paragraph 16.—Regarding the carrying capacity of piles, the speaker believes that the surest and easiest way to determine what a pile will carry is to make an actual test on the ground, by driving test piles and loading them. There will then be no uncertainty.

Paragraph 45.—As regards tie-rods, the speaker believes that they should not be omitted, even if the concrete slab system of flooring is used, but that in this case they should be placed near the top flanges of beams.

If tie-rods are omitted, as some of the makers of patented concrete systems suggest, there is always the likelihood of an accident occurring during erection, before the floor system is put in. The writer knows of two cases where beams, not being stayed with tie-rods, sprung sideways under a load, and caused serious accidents.

Paragraph 54.—Column splices should be designed to resist, not only bending strains, but twisting strains, in any direction, as this may come on them during erection.

There seems to be a tendency among some designers to cut the column splice down to the fine point, splice-plates are put only on two faces of the column, the angle lugs being omitted. The speaker does not consider this practice good. Mr. Stern.

The author says nothing regarding erection. The speaker believes that the supervision of the erection of the work which he has designed is one of the most important of the Engineer's duties, and thinks that the author might find a place for it in his specifications, to make them complete.

Many bad accidents have happened because proper supervision of the erection has not been given to work which has been properly designed.

The Engineer should have absolute control and supervision over the work which he has designed, and should have, besides, the power to pass on some things which are really outside of his own work, but which may affect its safety.

The erection of the steel, as a rule, is coincident with carrying up the walls and putting in the floors. Other trades will be at work on the building, and great care and vigilance must be exercised to prevent overloading the floors and straining the structure.

The speaker has seen a pile of cement, to be used later in floor arches, weighing 400 lb. per sq. ft., piled on a section of floor designed to carry a gross load of 125 lb. per sq. ft. Also, on the same floor, a pile of steel bars, to be used in re-inforcing the concrete floor, weighing 300 lb. per sq. ft.

Stone-setters, if not prevented, frequently attach booms to the columns of a building to hoist their stone to position. Hoisting engines are often placed on the first floor, and cause a great deal of vibration. They should either be placed in the cellar or shored up so that they clear the ironwork entirely.

Boom derricks, for erecting the ironwork, will probably require special temporary vertical bracing between the columns in those panels immediately adjoining the derrick. The stress which these derricks produce on the uncompleted structure is often much greater than that due to wind pressure.

CHARLES G. DARRACH, M. AM. SOC. C. E. (by letter).—If Mr. Schneider had presented his paper eighteen or twenty years ago much error would have been avoided, and money and lives would have been saved. The paper is valuable in many ways, and calls attention to the practice at the present time. Mr. Darrach.

To obtain the best results, capitalists must be made to recognize that the structural and mechanical engineers, as well as the architects, are absolutely necessary, and that it cannot be expected of the architect that he shall be an encyclopedia of knowledge.

The capitalist employs the architect at a flat 5% or less, and the

Mr. Darrach. architect (generally), in order to obtain a fair remuneration—or sometimes, even, make ends meet—depends for the most important details, which he could only get by association with engineers of knowledge and experience, either upon competing contractors, or upon the immature efforts of some ambitious graduate of a so-called scientific school.

The paper is admirable, yet it may be suggested that any hard and fast rule for the safe load on piles should be deprecated; the experience gained by the failure of the pile foundations under the western approaches of both the South Street and the Chestnut Street Bridges, over the Schuylkill River, in Philadelphia, Pa., are sufficient examples, and no pile foundations should ever be attempted without full knowledge obtained by ample and careful borings.

Although the paper, to a certain extent, refrains from discussing structural concrete, engineers should unqualifiedly condemn the common practice of using so-called cinder concrete. This cinder concrete is neither strong, water-proof, nor fire-proof, and hard-coal ashes are often substituted for cinders.

Floors should be made either of hard-burned brick, laid in Portland cement, or of good honest concrete made of trap or some other stone not affected by heat.

In a well-designed office building, the floor structure should be so designed that partitions can be erected in any location—or changed at the pleasure of the management. This condition places the partitions among the items making up the live load.

Mr. Johnson. L. J. JOHNSON, ASSOC. M. AM. SOC. C. E. (by letter).—As a supplement to his discussion of Mr. Schneider's paper,* the writer begs to present some additional data upon the weight of a crowd of people, the gist of which is to be seen in the three accompanying photographs, Figs. 1, 2 and 3, Plate XV, the most important of which is Fig. 1. These later results show that even the 160 lb. per sq. ft., mentioned previously, may be considerably exceeded.

In all the writer's previous experiments the men took their places in the enclosure entirely at random, with a maximum result of 156 lb. per sq. ft. Since, however, in crossing a bridge or in a packed assembly hall, all the people face one way, the experiments were continued to see how much a crowd of this kind would weigh. The same box (6 by 6 ft., inside measurement) as in Plates LIII and LIV* was used, and the men were selected, somewhat, seeking on the whole tall and preferably slender men. A result of 176.4 lb. per sq. ft. followed the first trial of this kind. Forty men, averaging 158.8 lb., entered the box, and the gate (in one of the sides) was shut

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* In *Proceedings*, Am. Soc. C. E., for December, 1904.

PLATE XV.
PAPERS, AM. SOC. C. E.
JANUARY, 1905.
JOHNSON ON
STRUCTURAL DESIGN OF BUILDINGS.

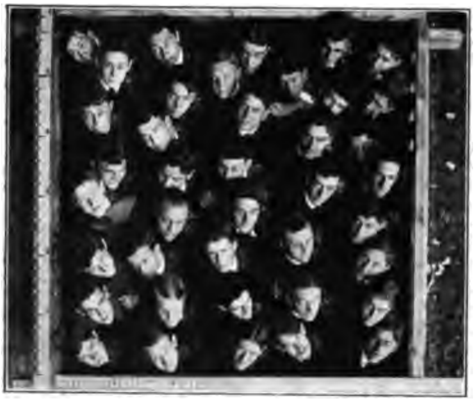

Fig. 1.—40 Men. Average Weight 163.2 Lb., or 181.3 Lb. per Sq. Ft.

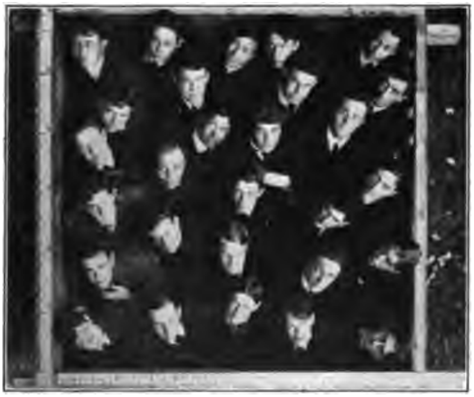

Fig. 2.—28 Men. Average Weight 167.7 Lb., or 130.4 Lb. per Sq. Ft.

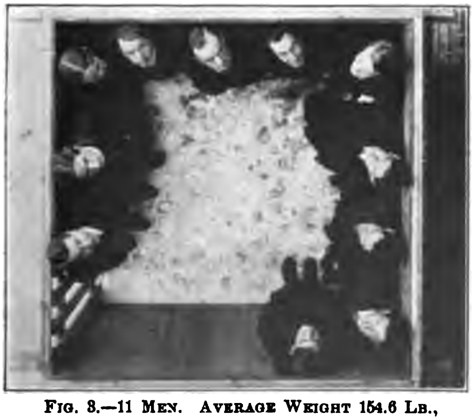

Fig. 3.—11 Men. Average Weight 154.6 Lb., or 47.2 Lb. per Sq. Ft.

Mr. Johnson.

and barred. Study of the resulting photograph showed that the maximum had not been reached, and the experiment was repeated with more care as to the selection of the men. The result was (Fig. 1, Plate XV) 181.3 lb. per sq. ft. from forty men averaging 163.2 lb. each. The men, all undergraduate students of engineering, ranged in weight from 119.6 to 203.1 lb., twelve of them weighing less than 150, and ten more than 175 lb. The stadia rods in the photograph furnish a means of verifying the size of the box, and the men may readily be counted. The figure, 181.3 lb. per sq. ft., may be looked upon as very close to the upper limit of the weight of a crowd of people, but a competent and careful observer of the test resulting in 176.4 lb. per sq. ft. declared that in his opinion the congestion did not differ much from that of the crowd on the drawbridge after foot-ball games, referred to previously, and this is borne out by the testimony of the men themselves. It will be freely admitted that if forty men, averaging 163 lb., can be made to stand in 36 sq. ft., forty men of the average size, 150 lb., could be placed there with comparative ease. Yet forty men of 150 lb. each would lead to 166.7 lb. per sq. ft. Further, if the five men in the rear row were to leave the box, the load would still be 166.0 lb. per sq. ft.

The pressure on the side walls of the box was not noticeably great, that upon the front and back walls was undoubtedly considerable, and the bracing shown in the cuts was provided accordingly. In making this experiment, the writer was inclined to be content with thirty-nine of these specially large men in the box, but those inside vociferously declared there was room for another, and it proved to be true.

It seemed worth while to procure for record a view of a crowd at about 125 lb. per sq. ft., and, accordingly, a picture (Fig. 2, Plate XV) was taken after twelve of the men in Fig. 1 had left the box. Those who left were among the lightest of the men, and the average of the remaining twenty-eight rose to 167.7 lb. The weight was 130.4 lb. per sq. ft.

Mr. Cooper's reference, earlier in this discussion, to 45 lb. per sq. ft. as the weight of the most densely packed crowds on the New York Elevated trains adds special interest to that figure. Accordingly, Fig. 3, Plate XV, was added, showing 47.2 lb. per sq. ft. It is due to eleven men, averaging 154.6 lb., standing in the same 36 sq. ft. as in the previous views. It does not accord at all with the writer's recollection of New York Elevated trains during rush hours.

It may be interesting to add that what may be called the asymptotic value of the weight of a crowd of men must be about 218 lb. per sq. ft. (possibly more than this rather than less, with men of varying height). This figure was reached upon examination of data kindly furnished by Dr. Sargent, Director of the Harvard

Mr. Johnson. Gymnasium. It was obtained by dividing the weight of a man, 6 ft. 3 in. tall, a former foot-ball captain, by his maximum horizontal cross-section as obtained by a planimeter. This maximum section, of course, was through the chest, including the arms. The weight of this man was 177 lb., and maximum cross-section was 117 sq. in., both quantities being exclusive of clothing.

With these photographs before him, the writer sees no escape from the conviction that crowds of 167 lb. per sq. ft. (forty average men in 36 sq. ft.) are entirely likely, and that from 130 to 140 lb. must be commonly reached in all places where crowds of people congregate standing. The careful designer, moreover, will remember that 180 lb. per sq. ft. is within the range of probabilities.

The margin of safety in many existing structures designed for from 80 to 100 lb. per sq. ft. (to say nothing of 40 to 45) must be much less than has been supposed. Probably the correct inference is that the experience of many years in many lands has demonstrated that the margin has been sufficient, nevertheless. Even if that be true, it is no reason why engineers should remain in the dark about how much a crowd of people actually weighs.

Perhaps the logical course to pursue now would be to increase the allowable working stresses so as to compensate to some extent for the increased loads actually assumed. Perhaps, on the other hand, the present unit stresses may properly be retained and more care be devoted to deciding for what portion of the possible maximum load special structures or parts of structures may properly be designed. This latter course seems the more scientific to the writer, but the subject thus opened is one which is always a fair field for the play of individual professional judgment, and into which the writer does not care to proceed farther at present. He begs to say, however, that he deplores the tendency, apparent in some quarters, to overlook the fact that a crowd of people is the very last load to be endangered by too low a margin of safety, even "once in a great while."

Mr. Shankland. E. C. SHANKLAND, M. AM. SOC. C. E. (by letter).—Mr. Schneider is to be complimented for presenting a paper so valuable, so exhaustive and so carefully worked out. He will have the thanks of all the members of the Society who have to do with structural work.

In this paper, it is difficult to find anything to criticise, or in which one differs from the ideas set forth and the conclusions drawn.

As regards live load, the amount provided for in the specification is ample. In 1891 the well-known contractor, the late George A. Fuller, weighed all the furniture in the main room of his offices in the Rookery, and also took the weights of a number of people whom he invited in, more than for whom he could provide seats, and more than had ever before been in the office at one time. The total weight was less than 10 lb. per sq. ft.

Mr. Shankland.

Mr. Fuller was very much opposed to the live load, as ordinarily considered. He favored a concentrated load on joists and girders, but did not favor carrying this load into the foundations. The writer does not believe it possible to get a uniform settlement with foundations not on solid rock, if live load is considered in designing them.

In the writer's opinion, the wind pressure called for, 30 lb. on the steel frame, is too high. The greatest velocity observed, at the office of the United States Weather Bureau in Chicago, since its establishment, was on February 12th, 1904, when a velocity of 115 miles was recorded, but the velocity for a 5-min. period was only 84 miles.

Some years ago the U. S. Weather Bureau re-rated their anemometers, and, disregarding the old Smeaton rule for determining the pressures, worked out a new formula, which they now use. According to this, the true velocity for an indicated velocity of 80 miles is 62.2 miles, and the corresponding pressure is 15.5 lb. per sq. ft. Other velocities and pressures are in the same ratio. Certainly, if the steel frame is designed to resist the ordinary wind pressure, the masonry walls, floors and partitions may be relied upon to enable the structure to withstand any greater wind which may occur.

Paragraph 7 should include the weight per square foot of skylights. In the roofs of courts there is generally nothing but glass and the steel frame.

The working pressures on masonry are too low. Hard-burned brick in Portland cement mortar will stand 20 tons safely; and Portland cement concrete properly mixed is good for 30 tons per sq. ft.

The author rules cast iron out of the specification on account of its very poor resistance to bending and tension. Cast-iron column bases are used quite generally, and are of much greater diameter than the columns they support, but the author must have had in mind only columns. Cast-iron columns should never be used where they have to resist either bending or tension, but there are many warehouses, several hundred feet square, and from 6 to 10 or 12 stories high, where the columns have to carry only a compression load, and in such cases the use of cast iron seems to be perfectly permissible. In many cases cast-iron columns can be had in very much less time than steel columns, and this renders their use desirable, even if difference in price is not considered.

It is not always possible to keep the depth of beams within one-twentieth of the span. Paragraph 45, limiting the deflection of beams to $\frac{1}{30}$ in. per foot of span covers the case and renders Paragraph 33 unnecessary.

For reasons before stated, in Paragraph 35 should be inserted

Mr. Shankland. the specification of the American Bridge Company for 1901, Paragraph 114.

In Paragraph 40 the writer thinks adjustable members for wind bracing and counters are preferable in building work; although they should be avoided in bridge work.

In a bridge, when the false work is taken out, the bridge settles down and takes up the play in the members, but in the case of a building no such condition obtains.

The same reasoning, if correct, applies to Paragraph 83.

Mr. Crowell. FOSTER CROWELL, M. AM. SOC. C. E. (by letter).—The introduction by the author of the feature of concentrated live loads on floors opens the way, as has been shown, for a logical and important reduction of assumed column loads, in the case of office buildings and apartment houses, the rational extent of which should be determined within consistent limits. The rule adopted for the reduction in the proposed specifications, Paragraph 10, is the current and official interpretation of the New York Building Code, Sec. 130, as therein stated. A comparative analysis of its application with that of a somewhat different interpretation is made in Table 19, which is simple and self-explanatory. The second interpretation is based, not on the theory that the actual floor loads would diminish from floor to floor, as the language of the rule would imply, but in consideration of the fact that the chances of full loads occurring simultaneously on every floor grow less and less as the number of floors increases; for present purposes, however, the arbitrary limitation of reduction to 50%, as in the rule, is retained.

By reference to Table 19 it will be at once noted that while a considerably greater reduction results from the second interpretation of the rule, the extreme effect is still well above (on the safe side of) the limit accepted by the author, on page 684,* and its "average total" agrees still more closely than the other with the investigations of Blackhall and Everett, to which he refers.

A little simple figuring from Table 19 shows that the resulting saving of column section would amount to 14% in the case of ten stories, 20% in twenty stories and 21% in thirty stories.

An inquiry into the inherent practicability of imposing even such reduced loads throughout a modern office building is of interest. If, for example, half the average live load is assumed to be due to furniture, safes, etc., and the remainder, or 10 lb. per sq. ft. of floor, to people, we can compute the number of persons of given average weight whom it would be necessary to introduce into and distribute through the building to make up the assumed total load on all the floors. The writer has made some observations of what may be termed the passenger capacity of some typical office buildings. Case I is a prominent and exceedingly populous building on lower Broadway in New York City, 16 stories in height above the street and occupying about 200 by 150 ft. of ground area. Assuming that 80% of the area is available floor space, the aggregate for the 15 floors dependent on elevator service is 360 000 sq. ft., and this, multiplied by 10 and divided by 150, representing the average weight per person, gives 24 000 as the number of persons who would have to be crowded into this particular building at one and the same time in order to subject it to the assumed loading. There are eight elevators, each with a crowded capacity of 12 persons besides the operator, capable of making 25 round trips each, or 200 in all, per hour. The total hourly passenger capacity thus would be 2 400 in one direction, and, to distribute 24 000 people would require 10 hours, during which period none would descend, which is a forced assumption and absurd on the face of it, but is essential to the completion of the loading. Case II (hypothetical) is a 10-story office building 100 by 100 ft., with 72 000 ft. of available floor space and 4 elevators holding 12 passengers and making each 30 trips per hour, making the combined hourly capacity 1 440 persons in one direction. In this case, on the same basis as before, 12 lb. per sq. ft. would be due to people, the number of persons to be distributed would be 5 760, and the time required to distribute them through the building would be 4 hours, with no persons descending. **Mr. Crowell.**

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* *Proceedings*, Am. Soc. C. E., for September, 1904.

While this comes nearer to being a supposable case than the other, it is evidently so improbable as to be practically impossible, and the conclusion seems to be warranted not only that the first interpretation of the rule is too conservative, but that for office buildings more than ten stories in height the limit of the second interpretation might consistently be lowered materially.

The columns which support stairways, main corridors, elevator landings and other parts of the building which are subject to heavy concentrations of people in case of the occurrence of a panic, from fire or otherwise, should not have any reduction, but, on the contrary, should be specially designed to meet properly the maximum concentrations, which might occur simultaneously on all the floors. Nor should there be any reduction in the case of warehouses, department stores or assembly halls.

The author is clearly correct in the reason given for the failure of some foundations proportioned for theoretical live loads which never occurred, and his suggestion to proportion for dead loads only, using a lowered modulus, is scientific, practical and a distinct advance. There is another category of unequal settlements to be guarded against, however, where the foundation loads may be practically identical, but where there are abrupt variations in the bearing power of the soil underlying adjacent parts of the same build-

Mr. Crowell. ing. Such differences frequently manifest themselves, during the progress of the work or previously, and can be readily compensated, but, in soils requiring pile foundations, especially, suitable adjustment of the foundation must be provided for in advance, based upon a careful determination of the variations by means of test-piles or otherwise. In cases where great variations of this nature occur, the pile-driving formula adopted by the author, Paragraph 16, must be modified to meet the conditions, or unequal settlement, in greater or less degree, will ensue.

TABLE 19.

RULE "A." SUCCESSIVE LIVE FLOOR LOADS REDUCED, BELOW THE TOP FLOOR, 5% EACH, UNTIL THE REDUCTION FACTOR IS 50 PER CENT.					RULE "B." SUCCESSIVE LIVE COLUMN LOADS REDUCED, BELOW THE COLUMNS SUPPORTING THE TOP FLOOR, 5% FROM THE NOMINAL TOTAL LIVE LOADS, UNTIL THE REDUCTION IS 50 PER CENT.	
	FLOOR LOADS, IN POUNDS PER SQUARE FOOT.					
Situation.	Successive "A."	Total "A."	Average "A."	Percentage.	Total "B."	Average "B."
Roof	50	....	....	....	50	....
1 (top floor)	40	90	40	100	90	40
2	38	128	39	95	126	38
3	36	164	38	90	158	36
4	34	198	37	85	186	34
5	32	230	36	80	210	32
6	30	260	35	75	230	30
7	28	288	34	70	246	28
8	26	314	33	65	258	26
9	24	338	32	60	266	24
10	22	360	31	55	270	22
11	20	380	30	50	270	20
12	20	400	29.16	....	290	20
13	20	420	28.46	....	310	20
14	20	440	27.86	....	330	20
15	20	460	27.33	....	350	20
16	20	480	26.87	....	370	20
17	20	500	26.47	....	390	20
18	20	520	26.11	....	410	20
19	20	540	25.79	....	430	20
20	20	560	25.50	....	450	20
21	20	580	25.24	....	470	20
22	20	600	25.00	....	490	20
23	20	620	24.78	....	510	20
24	20	640	24.58	....	530	20
25	20	660	24.40	....	550	20
26	20	680	24.23	....	570	20
27	20	700	24.07	....	590	20
28	20	720	23.93	....	610	20
29	20	740	23.79	....	630	20
30	20	760	23.66	....	650	20

NOTE.—The Roof Load is not taken into account in computing the averages of the floor loads in this table, but is included in the totals.

Mr. Crowell.

The reason for this has already been pointed out by the writer, in a paper presented before this Society,* but may be briefly repeated here. The effect of the introduction of the constant incremient in the denominator is inevitably to disproportion the rate of loading, causing it to be relatively less in the firmer soil and relatively greater in the more yielding, whereas the reverse should be aimed at.

As before stated, the writer regards the formula in question as safe and suitable for equal conditions. The suggestion is here offered that it would be well to expand Paragraph 16 to take in a steam-hammer formula, and also to cover concrete piles, now coming into extensive use, and to which the limitations of wooden piles do not apply. Usually, the concrete piles are not "driven" in the sense that wooden piles are, and it would seem important, taking this fact and others which suggest themselves into consideration, to formulate correct rules governing their use.

In the opinion of the writer, Paragraph 54 should be extended; he fully agrees that in dry situations the protection given to steel by the concrete is sufficient, and that, in such cases, the steel need not, and should not, be painted; but where subjected to alternate wet and dry conditions, or where the steel may not be completely surrounded and insulated by concrete in adhesion, further and more active measures should be taken than simply to omit the painting. In his own practice, the writer has specified as follows:

> "Such (steel) plates, and other steel members which are to be entirely imbedded in the concrete, must be carefully washed with acidulated water of sufficient strength to remove all grease and rust, and be well scrubbed; they shall then be washed with a hose jet of clean water neutralized with lime-water, and painted with a thin coat of neat cement just before the final covering with the concrete, which must be mixed and disposed so as to insure complete contact throughout with the steel. Steel members only partly imbedded in concrete, or in situations exposed to moisture acting through the concrete, must be treated, before leaving the shop, with two coats of * * * after having been thoroughly cleaned, as specified above."

Mr. Clarke.

ST. JOHN CLARKE, M. AM. SOC. C. E. (by letter).—It is gratifying, to those who have spent some time and effort in what has been called "Architectural Engineering," that an engineer of Mr. Schneider's attainments and prominence should present a paper on this subject so elaborately and carefully prepared. This one thing will do as much to elevate and dignify this branch of work as the subject-matter of the paper itself. Unfortunately, building work has been left largely to the "building trade," and has been neglected by the general engineering profession, to the disadvantage alike of buildings and of the Profession.

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* "Uniform Practice in Pile Driving." *Transactions*, Am. Soc. C. E., Vol. XXVII, pp. 106, 596.

Mr. Clarke. Comparing the author's specifications with the New York Building Law, it is evident that, for office buildings with the usual column spacing, the floor beams would be much heavier, the girders lighter and columns about 20% lighter, with greater uniformity in sizes and connections. A concentrated load of 5 000 lb. seems to be somewhat excessive. A safe weighing 5 000 lb. will rest on four points of support, and cannot be considered as a concentrated load on one point. With floor beams 20 ft. long, and spaced at 5-ft. centers, a concentrated load of 4 000 lb. is equivalent to 80 lb. per sq. ft., which, it would seem, is an ample allowance. The New York law requires 75 lb. per sq. ft. for live load, and this has given very good results in practice. The assumption of a concentrated load is more rational than the commonly assumed uniform load per square foot of floor, but the writer would make it less than 5 000 lb.

The author's requirement that the depth of beams and girders should be limited to one-twentieth of their span does not seem better than the old rule that the deflection shall be limited to $\frac{1}{30}$ in. for each foot of span. It is often impracticable to use beams or girders of only one-twentieth of their span.

The use of cast iron should certainly be discouraged; but, with discretion, it may be used for lintels, column bases, and even for columns in some instances. Cast iron, therefore, should receive some mention in tables giving permissible strains. The design of cast-iron bases is often most execrable.

In the matter of wind pressure the author is not quite clear. The writer interprets the specification as meaning that the steel frame is to be considered as an independent structure, subject to a wind pressure of 30 lb. per sq. ft. on its own area, and that the building, as a whole, is to be considered as subject to the same wind pressure, with walls, partitions and floors contributing resistance. This is a very broad requirement, and it would be hard to find two men to agree on its application to any one building. The conditions are peculiar to each case, requiring the exercise of care and judgment. The writer has frequently used 20 lb. per sq. ft. on the exposed surface of the building, considering the steel frame to supply all resistance, and increasing the permissible unit stresses 50% for the combined strains due to wind and other loading. This was done in deference to the requirements of law or precedent. In his judgment, this wind pressure might be reduced somewhat farther. If this were not true, many buildings, which are at present standing, would have fallen some time ago.

The use of the straight-line formula is to be commended for columns. Why should it not be used for wooden columns, also?

In Paragraphs 41 and 56, referring to symmetrical sections, attention should be called to the importance of balancing properly the connecting rivets about the center line or neutral axis.

The rules for spacing tie-rods and separators are rather arbitrary. **Mr. Clarke.** The allowable compressive values for concrete seem to be entirely too conservative. These values are an inheritance from the time when cement was not as good or as uniform as it is at present. From recent tests, it would seem that Portland cement concrete could be safely loaded to 35 tons per sq. ft. It may be objected that concrete of first-class quality cannot be depended upon. This objection is well taken, if the work is not done under proper supervision, but the use of these Specifications would seem to require the services of an engineer, and expert supervision should be expected for all work of this character.

Mr. Crehore. WILLIAM W. CREHORE, M. AM. SOC. C. E. (by letter).—The author has done the engineering profession a practical service by laying before it in a clear and concise manner a subject upon which there are wide differences of opinion, and by suggesting a specification which is more uniform and is better adapted exclusively to buildings than any other heretofore proposed. The subject is a very important one, and it is to be hoped that engineers will become sufficiently interested to work for the adoption of a uniform specification, which, if not indeed above criticism, will at least be entirely within the limits of good practice.

Probably there is a greater divergence of opinion among authorities on the subject of assumed live loading for floors than upon any other subject. As rain descendeth alike upon the just and upon the unjust, so municipal ordinances are made to govern both the skilled and the unskilled, and no discretion can be permitted to those whose knowledge of matters pertaining to building construction is perhaps of a higher order than that of the authors of the law. These laws usually err on the safe side, and are purposely made so. The writer's observation confirms that of the author and the authorities quoted, that the weight of an ordinarily crowded assemblage of people seldom if ever exceeds 40 to 50 lb. per sq. ft. This load, of course, is likely to occur not only in theatres, churches, schoolhouses and such buildings, but also in office buildings and hotels, and even in dwelling-houses. That is, whether a building is for public assemblages or not, it is likely to be loaded on rare occasions with throngs of people over small portions of its floor area; but, simply to provide for the dead weight of the live load (if the expression may be allowed) is admittedly not enough. A live load implies movement of some kind, and should be provided for according to its kind. The author covers this point by recommending that this load be doubled for places where strong vibrations may be expected, such as ball-rooms, drill-rooms, gymnasia, etc., and by limiting the span of the beams and girders to fifteen times their depth. The writer would make some increase in all classes of buildings, on

Mr. Crehore. the ground that dwelling-house and apartment-house floors, and the like, are occasionally subjected to vibration under their full load. The author's provision for a minimum concentrated load, of course, takes care of this point for all the shorter spans.

It is very easy to be deceived by one's observation in estimating the density of a crowd of people, because of the fact that their distributed weight per square foot varies inversely as the square of their distance apart. Assuming the average person to weigh 150 lb., if a crowd of people stood so close that each one occupied just 1 sq. ft. of floor space, the live load would then be 150 lb. per sq. ft. It is possible to squeeze people as close or even closer together than that, and there are congested localities in New York where this load frequently occurs. Now, assuming this assemblage to be spread out so as to become a 50-lb. live load, then the little square occupied by each person will contain 3 sq. ft. instead of 1, and will measure 1.732 ft. or 1 ft. 9 in. on a side. In other words, each person is now only 9 in. further from each of his neighbors in every direction, and yet the distributed load is reduced to one-third of its former amount. Table 20 gives the weights per square foot for different densities of crowds, varying by inches from 12 to 24 in., each person weighing 150 lb.

TABLE 20.

12 in. apart	150 lb.	19 in. apart	59 lb.
13 " "	127 "	20 " "	54 "
14 " "	110 "	21 " "	49 "
15 " "	96 "	22 " "	44 "
16 " "	84 "	23 " "	40 "
17 " "	75 "	24 " "	37½ "
18 " "	66 "		

The author's treatment of this whole subject leaves little to be desired. There is this about it, however. The very fact that it makes the computations for a building a little more complicated than the method at present in vogue, so that every architect's office boy will not be able to select the floor beams from the mill handbooks with reasonable exactness, will be likely to mitigate against its adoption by most municipal authorities. The tendency of municipal governments in this direction is to simplify and tabulate requirements for the use of the general public, and, where complications and ambiguity are likely to creep in, to select the alternative offering the greatest safety, regardless of economy. Until such time, therefore, as all work is required to be executed under the design and supervision of a licensed engineer or architect whose license depends upon his competency, the public welfare requires the existence of rigid, non-elastic legal regulations which can be easily applied by the layman, without the possibility of jeopardizing the

Mr. Crehore.

safety of construction by errors of omission or a misapprehension of the requirements. This fact, however, need not and should not prevent the adoption by engineers of a set of rational requirements aimed to secure a thoroughly uniform practice. A substantial agreement between engineers must certainly be brought about first, before any uniformity may be expected among the different municipal law makers.

In regard to the effect of vibrating loads on the structural frame of a building, something should be said about the very important part played by the floor construction itself. The writer agrees with the author that the steel frame of a building should be self-contained, that is, not dependent upon the other parts of the construction for rigidity or assistance of any kind. Nevertheless, a great deal of aid is given to the steel structure in the performance of its work by the walls and the fire-proof floor construction; and, in considering the subject of live loads, the ratio of the live to the dead load plays an important part. A vibratory load will impart motion to the supporting floor only after the inertia of the floor's dead weight has been overcome. In other words, only that portion of the impact which is not absorbed by the dead weight of the floor construction is left to impart motion to the structure. Thus, it will be seen, that a 40-lb. live load vibrating on a 35-lb. floor will affect the floor system, and consequently the beams and girders, far more than the same load would affect a 70-lb. floor. Yet even the 35-lb. floor will absorb some of the vibration, and it does not seem rational to compute the floor beams for the full effect of the vibration regardless of the inertia of the floor construction. The writer advocates adding to the live load a percentage for impact which shall vary with the ratio of the live to the dead load, according to some law to be determined either rationally or empirically.

As long as the load of a throng of people is assumed at 70 or 80 lb. per sq. ft. such refinement as the above is of no consequence at all; but, when it is proposed to assume the live load very close to what it actually is, it then becomes exceedingly important to take account of the effect of impact. Moreover, the effect of impact is very largely controlled by the dead weight of the floor construction itself. That these facts have been known all along, but perhaps not thoroughly realized, probably accounts for the wide divergence of opinion among municipal authorities on the subject of live loads; this divergence being primarily due to the different methods used to provide for this phase of the subject. The author's method of providing for it is eminently safe, and at the same time economical, but, in the writer's opinion, it is not fair to the fire-proofing companies, whose material forms the bulk of a floor's dead weight, to discriminate in favor of a light-weight floor construction; which is

Mr. Crehore. now a custom that Mr. Schneider's specification does not propose to amend. Not only the weight of the construction, but also the manner of laying it and the degree of completeness with which it is bonded with the beams and girders to form a homogeneous whole, are of great importance—in buildings as in bridges—in considering the effect a vibrating load has on the beams and girders; and a floor system which possesses these helpful qualities should not be discriminated against on account of its weight only, as is now done. By this the writer does not intend to convey the idea that there are no other considerations which should prevail in the choice of a floor construction, but merely to direct attention to the fact that the heavier floor is usually of more service than the lighter one in taking care of a vibrating load. The heavier floor, therefore, should be credited with a greater ability to absorb impact than the lighter floor has. This being done, a result might be obtained something like this:

	Heavy floor.	Light floor.
Actual dead weight of floor per square foot.	70 lb.	35 lb.
Assumed live load per square foot.........	40 "	40 "
Allowance for impact, per square foot.....	5 "	40 "
Total	115 lb.	115 lb.

This illustration is not given with any confidence that the allowance made for impact is proportionally correct, but merely to show that the net result affecting the floor beams might be identical in two cases where the dead loads were very far apart. Under this rational treatment of the calculations, therefore, much of the advantage apparently possessed by a comparatively light floor system must be surrendered. The same floor beams would be used in one case as in the other.

If, then, a tall building is properly constructed, a vibrating load should affect the beams very little, the girders even less, and the columns not at all. The excess added for impact (by whatsoever method), therefore, may be entirely disregarded for the columns and beyond. In addition to this, the author makes the very reasonable reduction of live load on columns amounting to 5% for each story until a reduction of 50% is reached. The writer agrees with this, but would go further, as just stated, and first deduct the whole original allowance for vibration or impact, before beginning to figure the 5% deductions.

Coming now to the foundations, it becomes evident that they will be affected by the live load least of all. The live load being a shifting quantity, constantly being transferred, and the total present at any one time actually being comparatively small, its share of

Mr. Crehore. the combined effect upon a yielding soil is seen to be unimportant. The author's method of proportioning the foundation areas for dead loads only, therefore, is about the only logically correct way to do it, under a legal requirement which includes the live load in the bearing unit. The writer has practiced this method for ten years or more, and is on record, as recommending it for general use, as long ago as 1896.*

It would be well to limit the use of cast-iron columns with side-bracket connections to the minimum size of an 8-in. column by 1-in. metal, permitting no smaller column unless its whole load is to be placed squarely on the top of the column. The maximum permissible load on side-bracket connections should also be specified, depending upon the thickness of the column, since most failures of cast brackets show the brackets to have pulled metal out of the main shaft, rather than to have broken off. The chief objection to cast iron is the difficulty in connecting to it in a way that will insure rigidity and stiffness. To connect an adequate system of wind bracing to cast-iron columns properly is an impossibility; and, because of the lack of rigid connections, the cast-iron-column building stands in greater need of wind bracing than the steel-column building. It is a worthy aim to make the structural frame entirely self-contained, yet it may not always be the economical way, for there is no denying the fact that well-built 12-in. and 16-in. curtain walls are great stiffeners; and, as they are to be in place anyway, they might as well be made of some use. The writer has sometimes been obliged to compromise in this matter, and has built several eight-story warehouse buildings of cast columns half way up and steel in the upper four stories, with excellent results. This permits putting in the stiffening where stiffening is most needed; and the heavier walls and columns of the lower part of the building lower its center of gravity, the walls providing ample filling to prevent vibration in the lower columns. This scheme also avoids the use of the smaller sizes of cast-iron columns.

As to the bearing power of piles, a maximum load of 20 tons will place the limiting height of a building on pile foundations at about twenty-eight to thirty stories. Piles cannot be properly driven and cut off if spaced much closer than 30 in. from center to center. If spaced 27 in. apart they will sustain the same load per square foot of ground area, allowing 20 tons per pile, as is permitted by the New York law for the unit bearing on good earth, namely, 4 tons. For their respective kinds of foundations, the Park Row Building and the St. Paul Building stand at about the limiting height possible under the present New York Code. To specify the maximum load at 20 tons for any kind or size of pile, seems to the writer to be

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* In a chapter contributed to Professor Du Bois' book, "Stresses in Framed Structures."

Mr. Crehore. rather unsatisfactory. It puts a premium on small piles. To be sure, the formula takes cognizance of the size of a pile, in a way, because, under the same blow, the larger pile will take less set than the smaller one. But the formula is based on the friction bearing of the pile, and, in the many cases where piles penetrate to hardpan or rock, the formula is inapplicable. There, the 20-ton limit applies. Certainly, a large and a small pile are not of equal value under these circumstances, nor is it a sufficient provision to limit the pile's bearing power by its average cross-section, regardless of its length or the kind of timber of which it is composed. In the writer's experience, he has had to deal with more cases where the formula was not applicable than where it was. It seems, therefore, that, in driving piles, a large amount of both common sense and good judgment are requisite, and any rules or formulas are of very little practical value, except under certain particular conditions.

Mr. Turner. C. A. P. TURNER, M. AM. SOC. C. E. (by letter).—The writer has read Mr. Schneider's paper with much interest, and only regrets that the author did not offer a specification for the truly modern type of building, namely, concrete-steel.

At present, the writer is constructing buildings of this type in competition with wood mill construction; and a comparison of the actual test loads which he guarantees to place on the finished floors for the various types of buildings, without damage to the construction, or evidence of undue weakness, may be of interest:

> Ordinary apartment-house floors, costing less than the old-style tile, with the steel frame left out, from 400 to 600 lb. per sq. ft., as may satisfy the owner;
>
> In warehouses, for which, in the older forms, the owner would be satisfied with a figured safe load of 500 lb. per sq. ft., the writer agrees to place a test load of 2 000 lb. per sq. ft., without damage to the construction, or evidence of weakness; and, in the last building on which he bid the figure was the same as for wood construction calculated for 500 lb. per sq. ft., and a factor of safety of 4. The floor area of this building was 9 acres in nine floors, or 1 acre per floor.

Naturally, in dealing with a type of construction in which the strength can be doubled with an increase in cost of 10%, or less, anything of the nature of a light or skinny specification for floor loads seems to be out of place, and it is natural to inquire whether the owner will continue long to prefer to pay 50% more for a type of construction which is only 20% as strong as the newer form, for no better reason than that heretofore it has been the custom.

MEMOIRS OF DECEASED MEMBERS.

NOTE.—Memoirs will be reproduced in the Volumes of *Transactions*. Any information which will amplify the records as here printed, or correct any errors, should be forwarded to the Secretary prior to the final publication.

JOHN MILLER CUNNINGHAM, Assoc. M. Am. Soc. C. E.*

DIED AUGUST 8TH, 1904.

John Miller Cunningham was born at Leavenworth, Kansas, on August 27th, 1865.

He was a student in the Class of 1888 of the Rensselaer Polytechnic Institute, and left after completing a special course in 1887. He worked himself upward from the position of draftsman in several institutions, gaining a wide experience, until, as Engineer for the Missouri Valley Bridge Company and the Toledo Bridge Company he entered the field of contracting, in Spokane, Washington, where he built the City Hall and numerous other structures in 1892.

Before the breaking out of the Spanish-American War, he had been engaged in New Orleans upon various constructions for several years prior to his enlistment. He enlisted in May, 1898, in Company C, 2d U. S. Volunteers (Immunes), of which he was First Lieutenant. While stationed at Santiago, he was detailed to raise the gunboat *Barnacoa*. After he was mustered out he returned to Pittsburg, Pennsylvania, where he immediately took up his profession with his accustomed energy.

He had a peculiar fitness for independent work, and possessed, to an unusual degree, that quality of an Engineer, which enables him to undertake with confidence the solution of intricate or involved problems.

To him, Engineering was his life and ambition, and the solution of problems but the incidents that gave it variety.

As an Engineer, he was daring, yet careful. His confidence and courage constituted him a conservative yet untiring worker.

He was married on June 22d, 1888, to Miss Josephine C. Geis, of Erie, Pennsylvania, who survives him.

While engaged in his profession, and while crossing the Mahoning River in the vicinity of his last field of action, the vehicle was suddenly overturned, and an active life full of promise passed away. His sudden demise was a shock to his friends and a loss to the profession.

Mr. Cunningham was elected an Associate Member of the American Society of Civil Engineers on October 7th, 1903, and was, also, had charge of the construction of pile platforms, racks and crib bulkheads for both terminals of the South Brooklyn Ferry; the location of the iron coal trestle and the construction of its pile and masonry foundation, for the Delaware and Hudson Canal Company at Weehawken, N. J.; the location and construction of column foundations for the Manhattan Elevated Railway Company for the connection of the Second and Third Avenue lines at the Harlem River, in addition to drafting and estimating on plans for bridges.

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* Memoir prepared by A. L. Schultz, M. Am. Soc. C. E.

From the fall of 1888 until the summer of 1890 Mr. Latham was employed as Assistant Engineer on the Brooklyn Union Elevated Railroad, first on estimating and drafting, and subsequently on construction; he had charge of the extension of the Fifth Avenue line from Twenty-fifth to Thirty-sixth Streets, in Brooklyn, and laid the track on this line south of Ninth Street.

From July, 1890, to May, 1894, he was employed on the Broadway Cable road, under Major G. W. McNulty, M. Am. Soc. C. E., and was Division Engineer in Charge of the work below Seventeenth Street, including the building of the power-houses at Houston Street and Front Street. This was one of the first and most difficult pieces of cable road construction in New York City, and involved the moving and changing of the sub-surface pipe system on an extensive scale. During 1895 and 1896 he constructed a short section of underground trolley work for the Love Electric Traction Company, building a double-track line from 186th to 194th Street, with the switches and terminal special work; he built the foundation for and set the boiler, engines and dynamos, and completed all the work essential to the safe and successful operation of this road.

During the latter part of 1896 he served in the United States Engineer Department, in the river and harbor work about New York City, particularly at Mt. Vernon, and at the Diamond Reef in the East River. From March, 1897, to 1899 he was Division Engineer for the Metropolitan Street Railway Company, during which time he had charge of building the Fourth Avenue electric railway line south of Forty-second Street, and the Second Avenue line south of Thirty-fourth Street, and all the switches and terminals in Astor Place, at Ninth, Sixth, Broome and Grand Streets.

In 1899 Mr. Latham became General Superintendent for Messrs. Naughton and Company, in building the Eighth Avenue railway line south of Fiftieth Street to Canal Street and Broadway, and in changing the motive power of the Third Avenue surface railway from cable to underground electric service; and changed over the tracks of the Boulevard line on Broadway between 122d and 126th Streets. This work consisted in moving each track 9 ft. sideways, so that they would be 51 ft. instead of 33 ft. apart, from center to center; the work was accomplished successfully and without accident, and the operation of the cars was maintained from the beginning to the end of the work without shutting off the power, stopping the cars or injuring any of the men.

Mr. Latham has thus been closely identified with steam railway and elevated and street railway construction; he was one of the builders of the first, most difficult and most successful of the cable railways in New York City, and subsequently rebuilt this line for use by the underground trolley and extended this construction over a great portion of New York City.

He was a skilful engineer, of excellent training, sound judgment and untiring industry; he was, besides this, a genial gentleman and a most honorable man in all his dealings with men, whether his employees, his associates or his subordinates; he was supremely conscientious in every performance of duty and in all the relations of life, methodical, painstaking and indefatigable in the practice of his profession. All who came to know him well learned to honor and respect him for his genuine worth.

On November 1st, 1888, Mr. Latham married Linda Howell Hackett, of Brooklyn, New York, who, with a daughter, Elizabeth Bell, survives him.

During 1903 he became identified with United States Government work near Albany, New York, pending the development of a railway project in that district, in which he was interested, and he died in Albany on November 10th of that year.

Mr. Latham was above all a manly man; he was modest and large-hearted, a Christian gentleman, a loyal friend, a devoted husband and father. His associates have lost a faithful and devoted friend, the profession a loyal and promising member, and the world a perfectly honest man.

Mr. Latham became a Junior of the American Society of Civil Engineers on July 3d, 1889.

PROCEEDINGS

OF THE

AMERICAN SOCIETY

OF

CIVIL ENGINEERS.

(INSTITUTED 1852.)

VOL. XXXI. No. 2.
FEBRUARY, 1905.

Edited by the Secretary, under the direction of the Committee on Publications.

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of presentation to the Society, are given.

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NEW YORK 1905.

Entered according to Act of Congress, by the AMERICAN SOCIETY OF CIVIL ENGINEERS
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◆

The House of the Society is open from 9 A.M. to 10 P.M. every day, except Sundays, Fourth of July, Thanksgiving Day and Christmas Day.

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Vol. XXXI. FEBRUARY, 1905. No. 2.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PROCEEDINGS.

This Society is not responsible, as a body, for the facts and opinions advanced in any of its publications.

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MINUTES OF MEETINGS.

OF THE SOCIETY.

FIFTY-SECOND ANNUAL MEETING.*

JANUARY 18TH, 1905.—The meeting was called to order at 10 A. M.; President Charles Hermany in the chair; Charles Warren Hunt, Secretary; and present, also, about 300 members.

The reading of the minutes of the meeting of January 4th was dispensed with.

Messrs. W. H. Coverdale, L. White and B. M. Wagner were appointed tellers to canvass the Ballot for Officers for the ensuing year.

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* A full report of the Fifty-second Annual Meeting is printed on pages 59 to 85 of this number of *Proceedings*.

The Annual Report of the Board of Direction and the Annual Reports of the Secretary and of the Treasurer[*] for the year ending December 31st, 1904, were presented, and, on motion, duly seconded, accepted and placed on file.

A progress report[†] from the Special Committee on Uniform Tests of Cement was read by the Secretary.

On motion, duly seconded, the report was received, placed on file, and the Committee continued.

A progress report[‡] from the Special Committee on Rail Sections was presented by Joseph T. Richards, M. Am. Soc. C. E., Acting Chairman of that Committee.

On motion, duly seconded, the report was received, placed on file, and the Committee continued.

A progress report[§] from the Special Committee on Concrete and Steel-Concrete was read by the Secretary.

The Chairman and Secretary of the Special Committee on Concrete and Steel-Concrete presented a request that the name of the Committee be changed to the Special Committee on Concrete and Reinforced Concrete.

On motion, duly seconded, the request was granted.

On motion, duly seconded, the report of the Committee was received, placed on file and the Committee continued.

The following were appointed members of the Nominating Committee for two years:

CHARLES L. HARRISON....	*Representing District No. 1.*
JOHN R. FREEMAN......	" " " *2.*
CHARLES F. STOWELL....	" " " *3.*
JAMES K. LYONS........	" " " *4.*
C. F. LOWETH..........	" " " *5.*
J. A. L. WADDELL.......	" " " *6.*
J. D. ISAACS............	" " " *7.*

The following resolution was presented by Samuel Whinery, M. Am. Soc. C. E., and duly seconded:

"(1) *Whereas,* It has been at times in the past, and may be in the future, suggested that members to serve on technical or other commissions, or to render special professional services, be nominated by the American Society of Civil Engineers, and

"(2) *Whereas,* No provision now exists in the Constitution or rules of the Society authorizing and governing the making of such nominations.

"(3) *Whereas,* It is proper and desirable that the attitude of the Society in reference to making such nominations shall be determined and expressed; therefore,

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[*] The Annual Reports of the Board of Direction, the Secretary and the Treasurer may be found on pages 10 to 22 of the *Proceedings* for January, 1905 (Vol. XXXI).

[†] See page 59.

[‡] See page 59.

[§] See page 60.

"*Resolved*, That the Board of Direction be requested to consider the propriety and advisability of the Society making such recommendations or nominations from among its own members, or others, for special positions or services; to take measures, if they shall deem it advisable, to ascertain the views of the membership on the subject; and to submit to the next Annual Convention its conclusions and recommendations in the matter."

After discussion, the resolution was adopted.

The Secretary reported that the Board of Direction had awarded the prizes for the year ending with the month of July, 1904, in accordance with the recommendations of the Committee appointed for that purpose, as follows:

That the Norman Medal be awarded to Paper No. 971, "The Breakwater at Buffalo, New York," by Emile Low, M. Am. Soc. C. E.

That the Thomas Fitch Rowland Prize be awarded to Paper No. 970, "Dock Improvements at Liverpool," by George Cecil Kenyon, Assoc. M. Am. Soc. C. E.

That the Collingwood Prize be awarded to Paper No. 976, "The Substructure of Marsh River Bridge," by Herbert J. Wild, Jun. Am. Soc. C. E.

The Secretary announced the election, by the unanimous vote of the Board of Direction and of all living Past-Presidents, of the following as Honorary Members of the Society:

SIR WILLIAM HENRY WHITE, of London, England.
ROBERT BENNETT GORSUCH, of Mexico.

The Secretary announced that the Thirty-seventh Annual Convention of the Society would be held at Cleveland, Ohio, on June 20th to 23d, 1905, and that the following Committees have been appointed to take charge of the arrangements:

COMMITTEE OF THE BOARD OF DIRECTION.

ALFRED CRAVEN, CHAS. WARREN HUNT,
NELSON P. LEWIS, WILLIAM J. WILGUS,
CHAS. S. GOWEN.

LOCAL COMMITTEE OF ARRANGEMENTS.

A. MORDECAI, *Chairman;*

WM. J. CARTER,
E. A. HANDY,
A. W. JOHNSTON,
M. W. KINGSLEY,
J. FRANCIS LE BARON,
F. C. OSBORN,
W. P. RICE,
J. RITCHIE,
S. T. WELLMAN,
C. H. WRIGHT.

The Secretary read a letter* from Chas. H. Snow, M. Am. Soc. C. E., inviting members of the Society to attend a lecture on the Goldschmidt Thermite process, at 4.30 P. M. on Thursday, January 19th, 1905.

The Secretary presented the report† of the tellers appointed to canvass the Ballot for Officers for the ensuing year.

The President announced the election of the following officers:

President, to serve one year:
C. C. SCHNEIDER, New York City.

Vice-Presidents, to serve two years:
M. L. HOLMAN, St. Louis, Mo.
EMIL KUICHLING, New York City.

Treasurer, to serve one year:
JOSEPH M. KNAP, New York City.

Directors, to serve three years:
District No. 1.—AUSTIN L. BOWMAN, New York City.
District No. 1.—MORRIS R. SHERRERD,
District No. 2.—HEZEKIAH BISSELL,
District No. 3.—WILLIAM B. LANDRETH,
District No. 3.—E. A. FISHER,
District No. 5.—GEORGE S. PIERSON,

Mr. Hague and Mr. C. S. Gowen conducted Mr. Schneider, the President-elect, to the chair.

Mr. Schneider addressed the meeting briefly.

Adjourned.

February 1st, 1905.—The meeting was called to order at 8.40 P. M., President C. C. Schneider in the chair; Chas. Warren Hunt, Secretary; and present, also, 92 members and 10 guests.

The minutes of the meeting of January 4th, 1905, were approved as printed in the *Proceedings* for January, 1905.

A paper entitled "Maximum Rates of Rainfall at Boston," by Charles W. Sherman, M. Am. Soc. C. E., was presented by the Secretary, who also presented a written communication on the subject from Kenneth Allen, M. Am. Soc. C. E.

The paper was discussed by Messrs. C. E. Gregory, W. M. Venable and E. Kuichling.

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* See page 74.

† See page 76.

Ballots for membership were canvassed, and the following candidates elected:

As Members.

Willlam Carl Brohm, Louisville, Ky.
William Crozier, Washington, D. C.
Charles Stratton Davis, Toledo, Ohio.
Tokichi Endo, Osaka, Japan.
Louis Prevost Gaston, Somerville, N. J.
Luis Augusto Huergo, Buenos Aires, Argentine Republic.
Charles Humphreys, Wheeling, W. Va.
Curtis Edwin Knickerbocker, Middletown, N. Y.
Arthur Jones Rockwood, Rochester, N. Y.
Raphael Chart Smead, Washington, D. C.
Frank McClellan Sylvester, Norfolk, Va.
Edward Everett Wall, St. Louis, Mo.

As Associate Members.

William Stuart Babcock, New Haven, Conn.
Francis Wheelwright Belknap, New York City.
Rodman Merritt Brown, Chicago, Ill.
Russell Chase, North Fork, Cal.
Louis Gillespie Fenton, New York City.
Herluf Trolle Forchhammer, Newark, N. J.
Hermann Fougner, Johannesburg, South Africa.
Albert Henry Greenwood, Elizabeth, N. J.
Frank Dudley Holbrook, Wellsburg, W. Va.
Alexander Rieman Holliday, Indianapolis, Ind.
Harry Alfred Lane, Cumberland, Md.
Louis Ralph Lavalle, Johannesburg, South Africa.
Ora Miner Leland, Ithaca, N. Y.
William Joseph Lightfoot, Montrose, Colo.
Henry Bennett Machen, New York City.
Walter Wesley McLaughlin, Logan, Utah.
Chauncy Rusch Perry, Boston, Mass.
Nathan Herbert Sanderson, Boston, Mass.
Ulrich Taubenheim, Archangel, Russia.
Noble Earl Whitford, Albany, N. Y.

The Secretary announced:

The transfer of the following candidates, by the Board of Direction, on January 31st, 1905:

From Associate Member to Member.

Edwin Griggs Adams, Jr., Tientsin, China.
Samuel Jefferson Chapleau, Ottawa, Ont., Canada.
George Lewis Christy, New York City.
Hermann Meriwether Knapp, Cincinnati, Ohio.

George Washington Lilly, Columbus, Ohio.
Gerard Hendrik Matthes, Lawton, Okla.
Charles Sterling Millard, Indianapolis, Ind.
Joseph Bodine Wright, New York City.

From Associate to Member.

Wolfgang Gustav Triest, New York City.

From Associate to Associate Member.

Fred Lincoln Stearns, New York City.

The election of the following candidates by the Board of Direction:

As Juniors.

On January 3d, 1905,
Stuart Augustus Stephenson, Jr., Newark, N. J.
On January 31st, 1905,
Elmer Ellsworth Barnard, Lynchburg, Va.
Robert Edward Barrett, Framingham, Mass.
Walter Frederick Reichardt, Little Rock, Ark.

The Secretary announced the following deaths:

Macy Stanton Pope, elected Associate Member May 2d, 1900; died December 10th, 1904.

William Beswick Myers-Beswick, elected Member January 3d, 1894; died December 27th, 1904.

Henry Brigham Looker, elected Associate Member May 3d, 1893; died January 5th, 1905.

Cassius Howard Lindenberger, elected Associate February 2d, 1892; died January 5th, 1905.

George William Frank, elected Member February 1st, 1899; died January 19th, 1905.

Edward Sherman Gould, elected Member November 4th, 1885; died January 24th, 1905.

Adjourned.

February 15th, 1905.—The meeting was called to order at 8.45 p. m., Vice-President Kuichling in the chair; Chas. Warren Hunt, Secretary; and present, also, 108 members and 19 guests.

A paper, entitled "The Water-Works of Porterville, California," by Philip E. Harroun, M. Am. Soc. C. E., was presented by the Secretary, who also read a communication on the paper from D. C. Henny, M. Am. Soc. C. E.

The subject was discussed orally by Messrs. H. F. Dunham, G. W. Tillson, H. J. Howe, G. L. Christian and W. M. Venable.

The Secretary announced the death of Casimir Constable, elected Member June 17th, 1868; died February 6th, 1905.

Adjourned.

OF THE BOARD OF DIRECTION.

(Abstract.)

January 18th, 1905.—The Board met during the Annual Meeting, as required by the Constitution, C. C. Schneider in the chair; Chas. Warren Hunt, Secretary, and present, also, Messrs. Bissell, Bowman, Craven, Croes, Davison, Deyo, Ellis, Fisher, Gowen, Hermany, Knap, Kuichling, Landreth, N. P. Lewis, Modjeski, Noble, Osgood, Sherrerd, and Webster.

The following Standing Committees were appointed:

Finance Committee: S. L. F. Deyo, Chas. S. Gowen, M. L. Holman, Emil Kuichling, George S. Pierson.

Publication Committee: Joseph O. Osgood, Alfred Craven, M. R. Sherrerd, Geo. S. Davison, Hunter McDonald.

Library Committee: Nelson P. Lewis, E. C. Lewis, H. Bissell, Ralph Modjeski, Chas. Warren Hunt.

A Committee on Membership was also appointed.

Mr. Hunt then retired.

Chas. Warren Hunt was unanimously elected Secretary for the ensuing year. Mr. Hunt, having been advised of his election, returned.

Joseph T. Richards, M. Am. Soc. C. E., was appointed Chairman of the Special Committee on Rail Sections.

E. C. Carter, M. Am. Soc. C. E., was appointed a member of the Special Committee on Rail Sections.

Adjourned.

January 31st, 1905.—8.35 P. M.—President Schneider in the chair, Chas. Warren Hunt, Secretary, and present, also, Messrs. Bowman, Bissell, Deyo, Gowen, Knap, Kuichling, N. P. Lewis, Noble, and Osgood.

A committee was appointed to consider the resolution referred to the Board at the Annual Meeting.

Messrs. Harry Fuller and W. H. Searles were added to the Committee of Arrangements for the Annual Convention.

The following resolutions were unanimously adopted:

"*Resolved,* That the thanks of the American Society of Civil Engineers be extended to the Pennsylvania Railroad Company for its great courtesy in furnishing, for the use of the Society at its Annual Meeting, January 19th, 1905, facilities, including a special train, for the inspection of the work at the new freight terminal at Greenville, N. J., which enabled such a large party of its members to inspect this interesting development."

"*Resolved,* That the thanks of the American Society of Civil Engineers be extended to the Long Island Railroad Company for its great courtesy, in placing at the disposal of the Society the steamer *Sagamore* on the occasion of its Annual Meeting, January

19th, 1905, which enabled a large number of the members of the Society to spend a most enjoyable sail in a visit to the new freight terminal of the Pennsylvania Railroad at Greenville, N. J., and the new drawbridge of the Central Railroad of New Jersey."

Applications were considered and other routine business transacted.

Eight Associate Members and one Associate were transferred to the grade of Member, one Associate was transferred to the grade of Associate Member, and four candidates were elected Juniors.

Adjourned.

REPORT IN FULL OF THE FIFTY-SECOND ANNUAL MEETING, JANUARY 18th AND 19th, 1905.

Meeting Called to Order.

Wednesday, January 18th, 1905.—The meeting was called to order at 10 A. M.; President Charles Hermany in the chair; Charles Warren Hunt, Secretary, and present, also, about 300 members.

The President.—The meeting will please come to order. The minutes of the meeting of January 4th, 1905, in accordance with the custom, will be printed in the January number of *Proceedings*, and come up in due course for action at the meeting of February 1st, 1905. In view of this fact, the reading of the minutes will be dispensed with, unless some call is made for them.

Tellers appointed.

The next in order is the appointment of tellers to canvass the Ballot for Officers. The Chair will appoint William H. Coverdale, L. White and B. M. Wagner. The ballot does not close until twelve o'clock, noon, but in order to enable a report to be made as soon as possible after that time, the canvass will proceed. Ballots will be received up to twelve o'clock, noon, and at that hour the ballot will be declared closed.

Report of the Board of Direction.

The next business in order is the annual report of the Board of Direction, to be presented by the Secretary.

The Secretary read the report of the Board of Direction.*

On motion, duly seconded, the report of the Board of Direction was received and placed on file.

The President.—The next business in order is the Annual Report of the Secretary.

The Secretary read his report.†

On motion, duly seconded, the report of the Secretary was received and placed on file.

The President.—The annual report of the Treasurer, Mr. Knap.

The Treasurer read his report.‡

On motion, duly seconded, the report of the Treasurer was received and placed on file.

Report of Cement Committee.

The President.—The next business in order is the reports of Special Committees. First "On Uniform Tests of Cement." The Secretary has the report of this Committee.

The Secretary read the report of the Committee on "Uniform Tests of Cement," as follows:

January 18th, 1905.

To the President and Members,
American Society of Civil Engineers.

Gentlemen:

The investigations now in progress have not advanced sufficiently to reach definite conclusions, and your Committee on Uni-

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* See *Proceedings*, Vol. XXXI, p. 10 (January, 1905).
† See *Proceedings*, Vol. XXXI, p. 20 (January, 1905).
‡ See *Proceedings*, Vol. XXXI, p. 22 (January, 1905).

Report of Cement Committee (continued).

form Methods of Tests of Cement is unable to present a final report at this time, and it asks therefore that it be continued.

GEO. S. WEBSTER,
Chairman;
RICHARD L. HUMPHREY,
Secretary.

Committee:
GEORGE F. SWAIN,
ALFRED NOBLE,
LOUIS C. SABIN,
CLIFFORD RICHARDSON,
SPENCER B. NEWBERRY,
W. B. W. HOWE,
F. H. LEWIS.

THE PRESIDENT.—Gentlemen, what will you do with the report?

It was moved and seconded that the report be received and placed on file, and that the request of the Committee, that it be continued, be approved.

The motion was carried.

Report of Committee on Rail Sections.

THE PRESIDENT.—The next report is from the Committee on the subject of "Rail Sections." The late L. F. G. Bouscaren was Chairman of this Committee.

JOSEPH T. RICHARDS, M. Am. Soc. C. E.—The report of the Special Committee on Rail Sections is as follows:

REPORT OF THE SPECIAL COMMITTEE ON RAIL SECTIONS.

Your Committee respectfully report that during the year they have given consideration to the work of committees on rail specifications which have been appointed by The American Railway and Maintenance-of-Way Association, The American Society for Testing Materials, and the Engineering Standards Committee (Great Britain), and with which Committees yours is working in harmony.

Your Committee has also obtained and discussed data pertaining to the service of rails made by different metallurgical processes, and under various specifications. In addition to this, they are keeping record of the use by American and other railways of rails of the American Society's sections.

In the judgment of your Committee all of this will enable them to make later a more definite report to the Society. However, in the meantime, they would report that correspondence with the Engineers of the Railways of the United States and Canada, evidences that while the wear of the heavier sectioned rails is not so satisfactory as that of the lighter ones, at the same time, there is not a demand on the part of said railways for a change in any of the American Society's sections. In addition to this, a conference with a committee representing American Steel Rail Manufacturers elicited from said Committee the statement that the manufacturers were entirely satisfied with the American Society's sections.

In view of the above, your Committee does not now recommend any change in the American Society's sections.

Inasmuch as the Committees of the several Societies above named hope soon to reach definite conclusions, and in view of the International Railway Congress to be held in Washington, D. C., in May next, your Committee think it well that their labors be continued, and therefore respectfully ask for such authority.

JOSEPH T. RICHARDS,
Acting Chairman.

JANUARY 18TH, 1905.

THE PRESIDENT.—Gentlemen, you have heard the report on "Rail Sections." What will you do with it?

It was moved, and duly seconded, that the report be received and placed on file, and that the Committee be continued.

The motion was carried.

Report of Committee on Concrete and Concrete Steel.

THE PRESIDENT.—The next business in order is the report of the Committee on Concrete and Concrete-Steel. Mr. C. C. Schneider is the Chairman of that Committee.

C. C. SCHNEIDER, M. Am. Soc. C. E.—The Secretary of the Committee, Mr. Schaub, has the report. At the same time I would announce that your Committee has requested him to read it.

J. W. SCHAUB, M. Am. Soc. C. E.—I would ask that Mr. Hunt read the report.

The Secretary read the report of the Committee.

JANUARY 17TH, 1905.

To the President and Board of Direction of the

AMERICAN SOCIETY OF CIVIL ENGINEERS:

Your Special Committee on Concrete and Steel-Concrete begs leave to report:

The first meeting of the Committee was held at Atlantic City, N. J., June 16th, 1904, at which there were present the members appointed.

The first business before your Committee was the recommendation of a proper descriptive name for a combination of Concrete and Steel. After careful consideration the name Reinforced Concrete was unanimously adopted as a proper term for this combination of Steel and Concrete.

Your Committee was instructed to co-operate with other societies desiring to assist in the investigations proposed. In pursuance with these instructions your Committee invited representation from the American Railway Engineering and Maintenance-of-Way Association, American Society for Testing Materials, and the Association of Portland Cement Manufacturers.

Subsequent to the first meeting of your Committee a second meeting was held, at which representatives of the Associations above named were present. As a result of this meeting, and a later meeting, held at St. Louis, at the time of your meeting in that city, Report of Committee on Concrete and Concrete-Steel (continued).

in October, 1904, Sub-Committees were appointed on "Plan and Scope," "Ways and Means," and on "Tests."

These Committees started in with their work, and, as a result, a tentative outline of the work contemplated by this body was unanimously adopted, and which is appended to this report. When it is finally made a record of the work, an Historical Sketch of the art of concrete and reinforced concrete will be made a part of the final report of your Committee.

The Committee on Tests has put itself in communication with some twelve colleges, and has received co-operation from them in the making of tests, and in the work suggested by the Plan and Scope Committee. Materials have been provided of a uniform character and standard for the experiments to be made, and a careful inspection is to be had, so that when all of the tests are correlated the results will be of standard and uniform character.

The Committee on Ways and Means has undertaken to provide funds for the carrying out of the work, such as the cost of inspection and experiments necessary, by soliciting contributions from the various societies associated with your Committee, and from the railroads, manufacturers, philanthropists, and others interested in this work.

Your Committee met again, both as a Joint Committee, and as a Committee of your Society, at the Society House, on January 17th, 1905, and adopted rules and by-laws for the government of its members, and approved of the work so far done by the several Committees.

It is hoped that during the coming year a sufficient number of tests will be made in many of the branches as suggested by the Sub-Committee on Plan and Scope to give some rules for governing Concrete and Reinforced Concrete construction, although the general work outlined by the Plan and Scope Committee may cover more than a single year.

The report of your Committee is submitted, together with the report of the Sub-Committee on Plan and Scope.*

Respectfully,
C. C. SCHNEIDER, *Chairman;*
JOHN E. GREINER,
W. K. HATT,
OLAF HOFF,
R. W. LESLEY,
EMIL SWENSSON,
A. N. TALBOT,
J. R. WORCESTER,
J. W. SCHAUB, *Secretary.*

It was moved and seconded that the reading of the report of the Sub-Committee be omitted, but that it be printed in the *Proceedings* of the Society.

The motion was carried.

THE SECRETARY.—There is a further report of this Committee, addressed to the Board of Direction, as follows:

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* See page 86.

NEW YORK, JANUARY 17TH, 1905.

Change in name of Committee on Concrete and Concrete Steel.

To the President and Board of Direction of the

AMERICAN SOCIETY OF CIVIL ENGINEERS:

It is the unanimous wish of the members of your Special Committee on Concrete and Steel-Concrete to have the name of this Committee changed to the Special Committee on Concrete and Reinforced Concrete.

The reason for this change is to adopt a name which is more descriptive of the purpose of your Committee.

C. C. SCHNEIDER,
Chairman;
J. W. SCHAUB,
Secretary.

It was moved and seconded that the request of the Committee, that the name be changed, be granted.

The motion was carried.

THE PRESIDENT.—Gentlemen, what will you do with the report of the Committee?

It was moved and seconded that the report be received and placed on file, and that the Committee be continued.

The motion was carried.

Nominating Committee.

THE PRESIDENT.—The next business in order is the appointment of members of the Nominating Committee from each of the seven geographical districts to serve for two years.

THE SECRETARY.—Mr. President, in accordance with the instructions of the Board of Direction, the suggestions for the members of the Nominating Committee from sub-districts have been tabulated, and are as follows.

I would like to say, however, before reading this report that a very large number of the suggestions have been received since the close of business yesterday, and up to that time a very careful count had been made and verified. There have been many ballots withdrawn and others substituted, and the Secretary does not know whether all of those ballots are absolutely correct; that is to say, there may be a man who has voted twice and there has been no time to verify this. He is inclined, however, to believe it is not so, but has not made that check.

District No. 1.—Total number of votes received, 341; distributed as follows:

CHARLES L. HARRISON	217
WILLIAM A. CATTELL	101
ARTHUR S. TUTTLE	3
J. J. R. CROES*	2

Nominating Committee (continued).

The following have received one vote each:

A. P. BOLLER,
L. L. BUCK,
ALBERT CARR,*
ST. JOHN CLARKE,
AMORY COFFIN,
JAMES H. EDWARDS,
A. I. FRYE,
GEORGE E. GIFFORD,
CHARLES H. GRAHAM,
O. E. HOVEY,
GEORGE A. JUST,
EUGENE KLAPP,
CHARLES H. MYERS,
F. S. ODELL,
JAMES OWEN,
WILLIAM BARCLAY PARSONS,
ROBERT RIDGWAY,
W. B. TRAVELL.

On motion, duly seconded, Charles L. Harrison, M. Am. Soc. C. E., was appointed a member of the Nominating Committee for the First District.

THE SECRETARY.—The nominations for District No. 2 are as follows:

District No. 2.—Total number of votes received, 57; distributed as follows:

JOHN R. FREEMAN....................	22
JOHN R. WORCESTER..................	4
GEORGE H. KIMBALL..................	3
C. FRANK ALLEN......................	2
LEONARD METCALF....................	2
HIRAM A. MILLER....................	2

The following have received one vote each:

CHARLES A. ALLEN,
DEXTER BRACKETT,
FRED. BROOKS,*
R. A. CAIRNS,
F. S. CURTIS,*
DESMOND FITZGERALD,
A. W. FRENCH,
B. W. GUPPY,
RICHARD A. HALE,
HENRY A. HERRICK,
ALBERT B. HILL,
WILLIAM JACKSON,*
W. H. MOORE,
HENRY MANLEY,
DWIGHT PORTER,
ARTHUR T. SAFFORD,
S. P. SENIOR,
C. W. SHERMAN,
GEORGE F. SWAIN,
S. E. TINKHAM,
F. O. WHITNEY,
HENRY B. WOOD.

On motion, duly seconded, John R. Freeman, M. Am. Soc. C. E., was appointed a member of the Nominating Committee for District No. 2.

THE SECRETARY.—The nominations for District No. 3 are as follows:

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* Ineligible.

District No. 3.—Total number of votes received, 52; distributed as follows:

Charles F. Stowell	14
Phelps Johnson	9
A. H. Sutermeister	3
Le Grand Brown	2
Palmer C. Ricketts	2

The following have received one vote each:

M. F. Bonzano,
E. A. Bond,
E. E. Brydone-Jack,
R. Cartwright,
C. L. Crandall,
E. A. Fisher,
William A. Haven,
William E. Hoyt,
Frank A. Hinds,
John Kennedy,
S. M. Kielland,
E. H. Keating,
O. H. Landreth,
William B. Landreth,
Emile Low,
E. H. McHenry,
C. M. Morse,
E. G. Spilsbury,
William F. Tye,
H. A. Van Alstyne,
E. H. Van Hoesen,*
J. Van der Hoek.

On motion, duly seconded, Charles F. Stowell, M. Am. Soc. C. E., was appointed a member of the Nominating Committee for District No. 3.

The Secretary.—The following are the nominations for District No. 4:

District No. 4.—Total number of votes received, 98; distributed as follows:

James K. Lyons	57
Edgar Marburg	7
Alexander Mackenzie	4
John C. Trautwine*	4
W. G. Wilkins	3
John Sterling Deans	2
J. V. W. Reynders	2

The following received one vote each:

J. A. Atwood,
A. Bonzano,
Mendes Cohen,
James Christie,
Robert A. Cummings,
George Davison,*
Emil Gerber,
John W. Hill,
David J. Howell,
Morris Knowles,
L. E. Johnson,
Robert W. Lesley,*
Mansfield Merriman,
S. P. Mitchell,
J. Madison Porter,
P. M. Sax,
Francis Lee Stuart,
Emil Swensson,
Thomas W. Symons.

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* Ineligible.

Nominating Committee (continued).

On motion, duly seconded, James K. Lyons, M. Am. Soc. C. E., was appointed a member of the Nominating Committee for District No. 4.

THE SECRETARY.—The following nominations are from District No. 5:

District No. 5.—Total number of votes received, 46; distributed as follows:

C. F. LOWETH	5
GARDNER S. WILLIAMS	4
M. J. RIGGS	3
J. B. DAVIS	2
E. A. HANDY	2
R. MODJESKI*	2
G. A. MARR	2
F. C. OSBORN	2
C. L. STROBEL	2

The following have received one vote each:

JOHN ALVORD,
W. L. BRECKENRIDGE,
M. J. CAPLES,
F. W. CAPPELEN,
E. C. CARTER,
L. E. CHAPIN,
F. L. CONDRON,
JOHN H. DARLING,
WILLIAM DE LA BARRE,
O. H. ERNST,
F. E. HOUSE,
M. A. HOWE,
R. W. HUNT,
W. M. HUGHES,
GEORGE W. KITTREDGE,
J. W. SCHAUB,
A. N. TALBOT,
HARRY E. TALBOTT,
WILLIAM D. TAYLOR,
H. U. WALLACE,
GEORGE Y. WISNER,
P. K. YATES.

On motion, duly seconded, Charles F. Loweth, M. Am. Soc. C. E., was appointed a member of the Nominating Committee for District No. 5.

THE SECRETARY.—The following is the ballot from District No. 6:

District No. 6.—Total number of votes received, 48; distributed as follows:

J. A. L. WADDELL	5
HUNTER MCDONALD*	3
C. S. CHURCHILL	2
J. W. KENDRICK	2
GEORGE E. EARL	2
A. PERRILLIAT	2

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* Ineligible.

The following have received one vote each:

Ward Baldwin,
D. Bontecou,
C. M. Bolton,
William Cain,
J. F. Coleman,
E. J. Chibas,
W. W. Coe,
W. H. Courtney,
William P. Craighill,
Edward Flad,
F. L. Goodale,
C. H. Goodale,†
William McL. Hall,
J. V. Hanna,
William E. Hutchings,
A. L. Johnson,
J. M. Johnson,
J. L. Ludlow,
R. Montfort,
E. Montfort,†
George B. Nicholson,
J. A. Ockerson,
J. A. Omberg, Jr.,
Hiram Phillips,
C. D. Purdon,
Henry M. Pharr,
A. M. Scott,
Miller A. Smith,
Henry M. Steele,
J. L. Van Ornum,
C. C. Wentworth,
Nisbet Wingfield.

On motion, duly seconded, J. A. L. Waddell, M. Am. Soc. C. E., was appointed a member of the Nominating Committee for the Sixth District.

The Secretary.—From District No. 7 the nominations are as follows:

District No. 7.—Total number of votes received, 46; distributed as follows:

J. D. Isaacs	4
Charles D. Marx*	4
Arthur L. Adams	2
J. B. Lippincott	2
Franklin Riffle*	2
Andrew Rosewater	2
H. A. Sumner	2
E. T. Wright	2

The following received one vote each:

R. B. Burns,
A. F. Doremus,
W. A. Drake,
F. W. D. Holbrook,
W. P. Holman,
Louis Kingman,
E. C. Kinney,
M. L. Lynch,
O. O. McReynolds,
F. O. Marvin,
S. D. Mason,
John Millis,
C. A. Morse,
C. E. Moore,
William S. Post,
J. H. Quinton,
D. W. Ross,
W. H. Saunders,
H. N. Savage,
James D. Schuyler,*
A. F. Sears,
W. B. Storey, Jr.,
R. H. Thompson,
Otto von Geldern,
J. H. Wallace,
B. S. Wathen.

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* Ineligible.
† Is not a member of the Society.

Nominating Committee (continued).

On motion, duly seconded, J. D. Isaacs, M. Am. Soc. C. E., was appointed a member of the Nominating Committee for the Seventh District.

THE PRESIDENT.—Before we hear the announcements from the Secretary, it is proper to inquire whether there is any member present who has any new business to offer at this meeting.

Resolution Relating to Appointment of Members on Commissions.

SAMUEL WHINERY, M. Am. Soc. C. E.—Mr. President, I wish to present a resolution, reading as follows:

> (1) *Whereas,* It has been at times in the past, and may be in the future, suggested that members to serve on technical or other commissions, or to render special professional services, be nominated by the American Society of Civil Engineers, and
>
> (2) *Whereas,* No provision now exists in the Constitution or rules of the Society authorizing and governing the making of such nominations.
>
> (3) *Whereas,* It is proper and desirable that the attitude of the Society in reference to making such nominations shall be determined and expressed; therefore,
>
> *Resolved,* That the Board of Direction be requested to consider the propriety and advisability of the Society making such recommendations or nominations from among its own members, or others, for special positions or services; to take measures, if they shall deem it advisable, to ascertain the views of the membership on the subject; and to submit to the next Annual Convention its conclusions and recommendations in the matter.

Mr. President, I move the adoption of that resolution.

The motion was seconded.

Discussion on Appointment of Members on Commissions.

THE PRESIDENT.—Gentlemen, this resolution involves a radical departure from the established usages of this Society. It is, therefore, not only in order now, but of great importance, to discuss the question. The discussion is in order.

MR. WHINERY.—It was not my intention, in presenting this resolution at this time, nor do I think it desirable, perhaps, in view of certain circumstances, that a general discussion of the main question be taken up at this time. It is, however, as the President says, a matter of very great importance. It is one about which the policy of the Society should be decided, and I know of no better or more satisfactory way of procedure than that outlined in the resolution, which is to refer the whole matter to the Board of Direction, to be considered and reported upon at the next Annual Convention of the Society. That will give time, not only for careful examination, and the whole question certainly deserves the most careful examination of the Board of Direction, but the very careful consideration of members of the Society. When the report of the Board of Direction is presented, it should then be, and I hope will be, very thoroughly discussed. There is, as the resolution states, no provision whatever in the present Constitution or Rules of the Society governing this matter. Such appointments have been suggested in the past and, as stated in the preamble, may be suggested or requested in the future. When such requests are made to us, it is usually urgent that action be taken promptly, and for that reason I think that the policy of the Society in relation to that whole question should be thoroughly threshed out and a decision reached, and, whatever that decision may be, carried into effect.

(Calls of "question.")

THE PRESIDENT.—Any further remarks?

J. J. R. CROES, Past-President, Am. Soc. C. E.—The policy of the Society, with reference to the appointment of experts, has been established, and has been very thoroughly established. There is no question about it. This raises the question whether or not the policy of the Society is to be reversed; whether a change is desirable. By referring this matter to the Board of Direction, you will bring up the question afresh. The policy of the Society is as fixed as possible, that it is not desirable, and never has been considered desirable or proper, that the American Society of Civil Engineers should interfere in the appointment or selection of persons for positions of trust. The resolution appears to be harmless on its face, but it is a question leading up to a radical change, and I, for one, will vote against the resolution being referred to the Board of Direction, of which I happen to be a member, and I don't think it is necessary or desirable that that question should be raised at this time at all.

(Applause.)

C. A. HAGUE, M. Am. Soc. C. E.—This question looks like the parting of the ways. It may lead to a better road; it may lead to a worse one. But it will probably be very valuable to look into the matter and see as far as may be where the road may lead to.

FOSTER CROWELL, M. Am. Soc. C. E.—I do not consider that the discussion of this subject is going necessarily to lead in one direction or the other, but, nevertheless, the difficulty which now exists is that the outside world supposes that the recommendation of this Society can be asked for and obtained in such matters. Whether or not it will be desirable to do that is the important question, as affecting the interests of the Society, which is the thing first of all to be considered. I think it is highly important that this investigation by the Board of Direction, and proper presentation of the subject before the Society, should be made, and I am heartily in favor of adopting the resolution, although I do not now feel either in favor or positively against it.

GEORGE HILL, M. Am. Soc. C. E.—It seems to me that in a

Discussion on Appointment of Members on Commissions (continued).

Society of so large a membership as this the entire membership should be given an opportunity to express an opinion on a question of such gravity as that resolution provides for. A vote against the resolution would deprive the large majority of our membership of the opportunity of expressing their opinion. The Society, in times past, has decided against any such action, but year by year the membership of the Society has increased enormously. It is possible, therefore, that year by year the feeling of the Society, as a whole, changes, and we certainly should bring up this question, a question of so much moment every few years, to ascertain surely what the opinion of the entire Society is, and not cut off any such opportunity at a meeting representing only a small fraction of the whole membership.

H. W. Brinckerhoff, M. Am. Soc. C. E.—I understood that the resolution provides for ascertaining by the Board of Direction the views of the Society. I would like to ask if the Society has been formally asked at any time past to make such recommendation? I know that it has been suggested, but I do not know if such a question has ever been asked. I would like to know what response has been made to such a request, if anything.

The Secretary.—I do not think I can go back far enough to answer that question.

A. P. Boller, M. Am. Soc. C. E.—I think I can answer that question, Mr. President. In 1885, or along there, the Society was asked to name a Commission to study the question of the terminal situation in the City of Providence, which, at that time, had been the cause of a great deal of contention between the citizens and the railroads, and on that Commission a selection was made from the Society, consisting of Mr. Don J. Whittemore, of Milwaukee; Mr. Joseph M. Wilson, of Philadelphia, and myself. Just how that was brought about, I do not know. Whether it was simply the action of the President, or whether it was the action of the Board of Direction, I do not know. But that Committee was appointed and acted as a Committee selected by the American Society of Civil Engineers at that time.

F. P. Stearns, M. Am. Soc. C. E.—I am inclined to favor this resolution, and will go just a word further to say that it seems to me undesirable, under the general circumstances, that this Society should appoint members or nominate men for different positions. But it seems to me, also, that it may make a great difference whether that request comes from some minor body, or people to whom the Society is not under obligations, or whether it comes in the form of some action by the Government—by the Government of the State of New York, for instance—and that there might be conditions under which it would be desirable that such nominations should be made.

That being the case, it is very desirable to have the opinion of the Society as to whether nominations should be made under any circumstances; but, in the mean time, such conditions may arise, and I do not know but what it might be that the Board of Direction could not act until it had referred the matter to the Society. It seems to me that the Board of Direction ought to be free to act if it sees fit to do so, notwithstanding this resolution; that is, it should not prevent the Board from acting if otherwise it would think best to act under its present powers.

Mr. WHINERY.—I think there is nothing whatever in the resolution that places any restraint upon the Board of Direction in any action it may take in the meantime, until the decision on this point is reached. The Board of Direction will remain as perfectly free to act in any cases that may come up in the immediate future as it is now.

(Several voices, "question.")

THE SECRETARY.—Pardon my calling attention to the fact that this resolution recites as follows:

> "*Whereas,* No provision now exists in the Constitution or rules of the Society authorizing and governing the making of such nominations."

Might that be construed to prevent the Board from acting?

Mr. WHINERY.—Mr. President, I think not. The fact, I think, is as stated in the resolution. Whatever action may have been taken by the Society heretofore or by its Board of Direction, there is, as far as I understand it, no provision whatever in the Constitution of the Society, no rule has been established by the Society, governing these cases, so that the resolution, in that respect, simply states the fact.

But I might add a few words to this effect: I think it is due, not only to the Society, but to the public at large, that the American Society of Civil Engineers should have a policy on this important question, and should be prepared to announce it promptly to the public. It is due to the public—particularly in view of the growing importance and influence of the American Society of Civil Engineers—it is due to the public that they should know the policy of the Society in that matter, so that no mistake may be made, so that, in ignorance of our policy, no public official shall recommend the passing of any law or Act of Congress which involves that question—which involves the composition of any Commission or the employment of any experts on the recommendation of the American Society of Civil Engineers. I have expressed no opinion upon the main question, at all, nor does the resolution express any opinion upon it, nor does it bind the Society to any action, whatever, in the meantime. It is merely a proposition to take up this subject and consider it, and, when so considered, to adopt the line of policy which will govern future conduct of the American Society of Civil Engineers, and the procedure of the Society in cases of this kind when they come up. It is evident here, and to most of the members of the Society, that there is wide difference of opinion upon the desirability of the Society undertaking any action of that kind. There being a decided difference of opinion on the subject, it is certainly proper, and it is certainly proper here and now, to take the matter up and consider it and arrive at a conclusion which will govern the future action of the Society. I do not wish to say anything in favor of either side of the question; I simply ask that the whole matter be taken up, considered and decided. (Applause.)

John Bogart, M. Am. Soc. C. E.—While it is true, I believe, that there is nothing in the Constitution of the Society touching upon this question, yet it is also true, as Mr. Croes has stated, that for many years there was adopted a decided policy by the Board of Direction upon this question.

I think that the appointment which Mr. Boller has referred to led to the adoption of that rule. Previous to that time, I do not think the matter had positively been settled, and that the appointment of that commission, or suggestion of that commission, was made at the time because the request for it was made, and then the members of the Society did not feel that there would be any objection to suggesting the names suggested. But the Board of Direction certainly did adopt a policy and I think the matter was discussed at a convention or annual meeting, a good many years ago, and a policy then adopted, I think, and that was: that it was not the function of the governing body of this Society to discriminate between its members for appointment to any position. Now, that has been the policy of the Society during the time when I was intimately connected with its management. I think the same policy has been followed ever since. Am I right on that?

The Secretary.—So far as I know.

Mr. Bogart.—I don't know that there is any objection to the matter being taken up again, and considered by the Board of Direction, and by the Society as a whole, but I do feel that there certainly is at the present moment that decided stand that the Board of Direction has not felt itself authorized—at the request of any board or body—to suggest to that board the name or names of members when there may be many other members who may be just as well fitted for a particular duty. It is only fair to the large number of members present who may discuss the question that I should explain it.

Edward P. North, M. Am. Soc. C. E.—Possibly I can refresh the last speaker's memory. I believe there were three appointments of experts or commissions, one referred to by Mr. Boller, the Rapid Transit Commission, and an expert on Philadelphia pavements. The appointment last mentioned made some little bad feeling, and, in consequence of that resolution of the Board—as I understand it, the year Mr. Bogart referred to was eighteen or twenty years ago—the Constitution of the Society was thoroughly revised. And I believe if you will look through that Constitution you will look through it without finding any power at all given to the Board of Direction to appoint any commissions or recommend any professional man. It was left so, as I understood it, rather than to have an interdiction of the thing with the understanding that, lacking power to do a thing the Board of Direction would not do it. I had a good deal of sympathy with that action of the Society at that time, and I have with it still, but in the course of eighteen years it might be advisable to have a change, and I think that Mr. Whinery's motion should prevail and we should have the understanding of the whole Society on this subject, which is a very important one. (Applause.)

Gardner S. Williams, M. Am. Soc. C. E.—One point I would call attention to: the word "authorize." It seems to me that it would perhaps be better to drop out the word "authorize" or the words "authorize and," and make use of the word "govern." As long as the word "authorize" stands there, the interpretation of the resolution would be that at present the Board is not empowered and decidedly is forbidden to deal with such propositions. If we take out that word "authorized" and substitute the word "govern" it leaves the Board to deal with the question. I am perfectly willing to trust the honor of the Society to our Board. I don't wish to prolong this by making this motion, but I ask that the author make the change.

Mr. Croes.—I think the word "authorize" ought to stand as it is in the resolution. (Applause.)

(Numerous voices, "question.")

The President.—Are you ready for the question?

(Several members, "question.")

The President.—You have heard the resolution offered by Mr. Whinery. It has been seconded and elaborately discussed. How will you have the vote taken, *viva voce* or by ballot?

(Many voices, "*viva voce*.")

The President.—Let those in favor of that resolution manifest it by saying "aye."

(Many "ayes.")

The President.—Contrary minded, if any, no.

(A few voices say "no.")

The President.—The motion is carried and the resolution adopted.

Award of Prizes.

Is there any further new business to be offered at this meeting? If not, the Secretary will make some announcements.

THE SECRETARY.—Mr. President, as to the report of the Committee appointed to recommend the award of prizes. It is dated November 30th, and addressed to the Secretary.

Nov. 30, 1904.

MR. CHAS. WARREN HUNT, SEC.,
AM. SOC. C. E.,
220 W. 57TH ST., NEW YORK.

DEAR SIR:

The undersigned Committee, appointed for this purpose, have the honor to recommend the award of prizes for the year ending with the *Transactions* for the month of July, 1904, as follows:

The Norman Medal to Mr. Emile Low for his paper No. 971 on The Breakwater at Buffalo, N. Y.

The Thomas Fitch Rowland Prize to Mr. George Cecil Kenyon for his paper No. 970 on Dock Improvements at Liverpool.

The Collingwood Prize for Juniors to Mr. Herbert J. Wild for his paper No. 976 on The Substructure of Marsh River Bridge.

Respectfully submitted,
CHARLES L. STROBEL,
SAMUEL TOBIAS WAGNER,
J. L. LUDLOW,
Members Committee.

I have to report, Mr. President, that at the meeting of the Board of Direction on January 3d, 1905, the recommendations of the Committee as stated were adopted and prizes awarded in accordance therewith. (Applause.)

Announcement of Election of Honorary Members.

I also have great pleasure in announcing the election, by the unanimous vote of the Board of Direction and all living Past-Presidents, of the following gentlemen as Honorary Members of the Society:

SIR WILLIAM HENRY WHITE, of London, England;

ROBERT BENNETT GORSUCH, of Mexico.

Mr. Gorsuch is the only living man who was present at the first meeting when this Society was organized in November, 1852. He was the first Secretary and Treasurer.

Invitation to Lecture on the Thermite Process.

I also have a letter which I have been asked to read. It is from Charles H. Snow, M. Am. Soc. C. E., of the New York University, and is addressed to the Secretary.

NEW YORK CITY, January 16, 1905.

MR. CHARLES WARREN HUNT, SECRETARY,
AMERICAN SOCIETY OF CIVIL ENGINEERS,
West 57 Street, City.

DEAR SIR:—

Mr. A. Stürz of the Goldschmidt Thermite Co. will describe the Goldschmidt Thermite process in the College Auditorium, Thursday, January 19, at four-thirty P. M. The lecture which will be given under the auspices of the Havemeyer Chemical Laboratory will be illustrated by the following experiments:

Reduction of Rare Metals.
The Heating Power of Thermite.
The Welding of a Rail.
The Repair of a Ruined Plate.
The Welding of a Pipe, etc.

New York University School of Applied Science extends a hearty invitation to any members who may care to attend this lecture. A train leaves Grand Central Station at 4:08. Tickets should be purchased to Morris Heights. The auditorium is located in sight on the hill to the north and is about ten minutes' walk from Morris Heights station.

Yours very truly,
CHAS H. SNOW.

Nov. 30, 1904.

Mr. Snow is a member of this Society, and Dean of the Engineering Faculty of New York University.

Announcements.

I think every member has a programme of the remainder of this meeting, and it will perhaps be unnecessary to read it. So far as the Secretary now knows, the programme will be carried out exactly as printed.

The President asks me to announce that a meeting of the Board of Direction of the Society will be held, directly after the adjournment of this meeting, in the office of the Secretary.

The tellers are very nearly finished with their count of the ballots, and, under the Constitution, the balloting for members cannot close until twelve o'clock. It is about a minute and a half to twelve now.

I am also requested, on behalf of the Chairman of the Committee of Arrangements for this meeting, to say that the Committee, after a great deal of careful thought, believes it can serve the lunch that is to be eaten at the Society House, at one o'clock or thereabouts, to-day, very well indeed if all members will be seated and keep as far away as possible from the table at which the caterer is to serve it. (Loud applause and much laughter.)

This is by special request of Mr. John W. Ellis.

THE PRESIDENT.—The hour of twelve o'clock having now arrived, it is in order for the Tellers on the Ballot for Officers to make their report. I should state that the hour of twelve having arrived, the ballot is closed and the report of the Tellers is now in order.

THE SECRETARY.—It is not quite ready, but I will go and see if I can hurry it a little.

THE PRESIDENT.—The Tellers are not quite ready to make their

Report of Tellers.

report, and therefore a recess will now be taken for five minutes, or such length of time as it requires to make its report.

(Recess.)

The President.—(After recess.) The Secretary will now read the report of Tellers.

The Secretary.—The Tellers report:

Report of Tellers Appointed to Canvass the Ballot for the Election of Officers at the Annual Meeting, January 18th, 1905.

Total number of ballots received	819
Defective	40
Total counted	779
For President:	
C. C. Schneider	763
E. L. Corthell	3
P. C. Ricketts	3
C. S. Gowen	1
G. B. Nicholson	1
O. F. Nichols	1
Mansfield Merriman	1
For Vice-Presidents:	
M. L. Holman	764
Emil Kuichling	759
W. J. Wilgus	2
R. Montfort	1
N. P. Lewis	1
P. C. Asserson	1
H. W. Hodge	1
A. Mackenzie	1
Emil Swensson	1
G. W. Rafter	1
James Dun	1
G. W. Catt	1
John Bogart	1
P. Alex. Peterson	1
S. G. Artingstall	1
For Treasurer:	
Joseph M. Knap	770
John Thomson	1
For Directors:	
A. L. Bowman	761
Morris R. Sherrerd	765
V. G. Bogue	1
R. C. Holliday	1
L. L. Tribus	1

George Gibbs	1
John Bogart	1
A. Lucius	1
C. L. Harrison	2
G. B. Francis	1
H. de B. Parsons	1
C. Davis	2
Hezekiah Bissell	769
E. P. Dawley	1
R. A. Cairns	1
William B. Landreth	767
E. A. Fisher	769
W. B. Cogswell	2
G. E. Ellis	1
C. S. Crandall	1
W. A. Haven	1
W. A. Brackenridge	1
George S. Pierson	768
H. G. Kelly	1
G. S. Williams	1
W. C. Jewell	1

W. H. Coverdale,
L. White,
B. M. Wagner,
Tellers.

Officers Elected.

The President.—According to the report of the Tellers, the following officers have been elected for the ensuing year:

As President, C. C. Schneider;

As Vice-Presidents, M. L. Holman and Emil Kuichling;

As Treasurer, Joseph M. Knap;

As Directors, A. L. Bowman, Morris R. Sherrerd, Hezekiah Bissell, William B. Landreth, E. A. Fisher and George S. Pierson.

The President.—The Chair will appoint Mr. Hague and Mr. Gowen as a Committee to conduct Mr. C. C. Schneider, the President, to the platform. (Loud and continued applause.)

President Schneider Introduced.

The President.—It gives me pleasure to introduce to you Mr. C. C. Schneider as President-elect of the American Society of Civil Engineers. (Great applause.)

Remarks by President Schneider.

President Schneider.—Members of the American Society of Civil Engineers, I take this opportunity to express my appreciation of the honor which you have conferred upon me by electing me to the highest and most honorable office within the reach of an engineer; an office which has been held by so many distinguished members of our profession that I feel somewhat timid lest I may not be as competent to fill this Chair as many of my illustrious

Remarks by President Schneider (continued).

predecessors. However, I will endeavor to perform my duties faithfully and conscientiously, remembering the welfare of the Society and the objects for which it is formed, namely, the advancement of engineering knowledge and practice, and the maintenance of a high professional standard among its members. I am confident I shall have your hearty support and co-operation in maintaining the high professional standard of this Society, which has been its great success, and not merely to maintain, but rather to improve the standard so that it may not be excelled by that of any other similar organization in the whole world. (Loud and continued applause.)

The Board of Direction meets immediately after the adjournment of this meeting. There being no other business before this meeting, a motion to adjourn is in order.

The meeting then adjourned.

EXCURSIONS AND ENTERTAINMENTS AT THE FIFTY-SECOND ANNUAL MEETING.

Wednesday, January 18th, 1905.—After the business meeting, lunch for about 450 members was served at 1.30 P. M. at the Society House. The afternoon was left free for individual recreation.

At 9 P. M. there was a Reception, with dancing, in the Society House, at which the attendance was about 300.

Thursday, January 19th, 1905.—The day was devoted to an excursion to the new Freight Terminal of the Pennsylvania Railroad at Greenville, N. J., by invitation of Samuel Rea, Fourth Vice-President, and William H. Brown, Chief Engineer.

The party met at the pier at the foot of East Thirty-fifth Street (East River) at 10 A. M. and embarked on the steamer *Sagamore,* kindly furnished through the courtesy of the Long Island Railroad Company. The sail down the East River and through New York Bay afforded an interesting panorama of engineering works. A landing was made at the Freight Terminal, and the piers and transfer bridges at Greenville were examined. Subsequently, the boat proceeded to Newark Bay, where the new lift-bridge of the Central Railroad of New Jersey was inspected. Lunch was served on the boat, and the party landed at the foot of Wall Street at about 3 P. M.

In the evening, at the Society House, W. H. Jaques, M. Am. Soc. C. E., gave an illustrated lecture on "The Development of Solar Evaporators." This was followed by a social and informal "Smoker," at which there was an attendance of about 450 members and guests.

The following list contains the names of 422 members, of various grades, who registered as being in attendance at the Annual Meeting. The list is incomplete, on account of the failure of many members to register, and it does not contain the names of any of the guests, of the Society or of individual members:

Abbot, F. W. . Philadelphia, Pa.
Allen, C. M. . Worcester, Mass.
Allen, Henry C. Syracuse, N. Y.
Allen, W. A. . . . New York City
Allen, W. H. . . . Brooklyn, N. Y.
Andrews, H. . . . . . Albany, N. Y.
Asserson, H. R. . Brooklyn, N. Y.
Averill, F. L. Washington, D. C.
Bacon, John W. . Danbury, Conn.
Bailey, Geo. I. . New York City
Baker, H. C., Jr. New York City
Baldwin, F. H. . Bayonne, N. J.
Baldwin, W. H. . Yonkers, N. Y.
Bamford, W. B. New York City
Bance, C. W. . . . Paterson, N. J.
Barney, P. C. . Brooklyn, N. Y.
Bartram, G. C. . . Boston, Mass.
Basinger, J. G. . New York City

Bates, O. . . . . Chicago, Ill.
Baum, G. . . . . . New York City
Beach, R. J. . . . New York City
Beerbower, G. M. New York City
Belzner, T. . . . . New York City
Bensel, J. A. . . . New York City
Berg, W. G. . . . New York City
Bettes, C. R., Far Rockaway, N. Y.
Beugler, E. J. . . . Boston, Mass.
Bishop, G. H. Middletown, Conn.
Bissell, H. . . . . . . Boston, Mass.
Blakeslee, C. New Haven, Conn.
Boecklin, W. . . New York City
Bogart, J. . . . . . New York City
Boller, A. P. . . . New York City
Bonzano, A. . . Philadelphia, Pa.
Bonzano, M. F. Philadelphia, Pa.
Bowman, A. L. . New York City
Brace, J. H. . . . New York City
Bramwell, G. W. New York City
Breithaupt, W. H., Berlin, Canada
Brendlinger, P. F., Philadelphia, Pa.
Breuchaud, J. . . Yonkers, N. Y.
Briggs, J. A. . . . New York City
Brinckerhoff, H. W., New York City
Brown, T. E. . . New York City
Brown, W. P. . . New York City
Brownell, E. H., Portsmouth, N. H.
Brownlee, J. L. New York City
Brunner, John. . . . Chicago, Ill.
Bryson, Andrew, New Castle, Del.
Buchholz, C. W. New York City
Buck, L. L., Hastings-on-Hudson, N. Y.
Buck, R. S. . . . . New York City
Butts, E. P. . Springfield, Mass.

Carter, S. . . . . Norfolk, Va.
Catt, G. W. . . . . New York City
Cattell, W. A. . . New York City
Chambers, H. J. New York City
Chambers, R. H. New York City
Chase, R. D. . . . New York City
Chester, J. N. . . . Pittsburg, Pa.
Christian, G. L. New York City
Christy, G. L. . . New York City
Clapp, Otis F. Providence, R. I.
Clark, G. H. . Birmingham, Ala.
Clark, L. V. . Philadelphia, Pa.
Clarke, G. C. . . . New York City
Clarke, St. John. . Bogota, N. J.
Clement, John B. New York City
Codwise, E. B. . Kingston, N. Y.
Coffin, Amory. . New York City
Coffin, F. C. . . . . . Boston, Mass.
Coffin, T. Amory. New York City
Cogswell, W. B. Syracuse, N. Y.
Collingwood, F. New York City
Coombs, S. E. . New York City
Cooper, Samuel L., Yonkers, N. Y.
Coverdale, W. H. New York City
Crandall, C. L. . . Ithaca, N. Y.
Crane, C. A. . . . New York City
Creuzbaur, R. W. New York City
Croes, J. J. R. . New York City
Crowell, Foster. New York City
Curtis, Varnum P., Worcester, Mass.

Dakin, A. H., Jr. New York City
Dana, R. T. . . . New York City
Davies, J. V. . . . New York City
Davis, Chandler. . New York City
Davis, Charles. . . Allegheny, Pa.
Davis, J. P. . . . New York City
Davis, R. B. . . . . Boston, Mass.
Davis, W. R. . . . Albany, N. Y.
Davison, G. S. . . . Pittsburg, Pa.
Dawley, E. P. . . . Boston, Mass.
Dean, Luther. . . Taunton, Mass.
Deyo, S. L. F. . New York City
Dorrance, W. T. New York City
Drew, C. D. . . . Brooklyn, N. Y.

Dunham, H. F. . New York City
Dunham, L. A. Kansas City, Mo.

Edwards, D. G. . New York City
Edwards, J. H. . . . Oxford, N. Y.
Ellis, J. W. . Woonsocket, R. I.
Erlandsen, O. . . New York City
Evans, L. H. . . . New York City
Evans, M. E. . . . New York City

Fairchild, J. F. . Pelham, N. Y.
Farley, G. P. . . . Wiscasset, Me.
Fernstrom, H. . New York City
Fisher, E. A. . Rochester, N. Y.
Fisher, Francis D., New York City
Flinn, A. D. . . . New York City
Ford, P. D. . . . . New York City
Ford, W. G. . . . . . Brooklyn, N. Y.
Ford, W. H. . Philadelphia, Pa.
Forgie, James. . New York City
Foster, T. J. . . . New York City
Fox, H. H. . . . Brooklyn, N. Y.
Foye, A. E. . . . . New York City
Francis, G. B. . New York City
Francis, H. N. Arlington, R. I.
Fraser, C. E. . . . New York City
Frazee, J. H. . . . New York City
French, A. H. . . . Boston, Mass.
French, A. W. . . . . Piqua, Ohio
Frost, G. S. . . . . New York City
Frye, Albert I. . Elizabeth, N. J.
Fuertes, James H., New York City
Fuller, Andrew D. Boston, Mass.
Fuller, W. B. . . New York City
Furber, W. C. Philadelphia, Pa.

Gartensteig, C. . New York City
Gifford, G. E. . . New York City
Gildersleeve, A. C., New York City
Giles, Robert. . . New York City
Gillespie, R. H. New York City
Gilman, C. . . . . New York City
Goad, C. E. . . . Toronto, Canada
Goddard, H. W. . New York City
Goodell, J. M. . New York City
Goodrich, E. P. . New York City
Gould, W. T. . . . New York City
Gowen, C. S. . . . Ossining, N. Y.
Graham, C. H. . New York City
Graham, J. M. . New York City
Granbery, J. H. Elizabeth, N. J.
Graves, E. D. . Hartford, Conn.
Gray, J. H. . . . . New York City
Greene, Carleton. New York City
Greenlaw, R. W. New York City
Greiner, J. E. . . Baltimore, Md.
Grimes, E. L. . . . . Troy, N. Y.
Grimm, C. R. . . Brooklyn, N. Y.
Gudmundson, G. . Pittsburg, Pa.

Hague, C. A. . . New York City
Haight, S. S. . . New York City
Haines, C. W. . . Richmond, Va.
Hale, H. M. . . . New York City
Hall, L. W. . . . Syracuse, N. Y.
Hall, Martin W. New York City
Hanavan, W. L. New York City
Harper, A. C. . . . Panama, C. M.
Harris, Charles M., New York City
Harrison, C. L. . New York City
Harrison, E. W., Jersey City, N. J.
Harte, C. R. . New Haven, Conn.
Harwood, G. A. . New York City
Haskins, W. J. . New York City
Hauck, W. . . . . . New York City
Hazen, Allen. . . New York City
Hemming, D. W. New York City
Henderson, J. T., Hartford, Conn.
Herbert, H. M., Bound Brook, N. J.
Hering, Rudolph. New York City
Hermany, Charles, Louisville, Ky.
Hewes, Virgil H. New York City
Hillyer, W. R., West Brighton, N. Y.

Hitchcock, F. C....Patton, Pa.
Hodgdon, Frank W., Boston, Mass.
Hodge, Henry W., New York City
Hogan, J. P...New York City
Hollyday, R. C. Brooklyn, N. Y.
Honness, G. G..Pawling, N. Y.
Horton, Sandford, New York City
Hough, D. L...New York City
Hovey, O. E...New York City
Howell, D. J. Washington, D. C.
Hubbell, C. W..Detroit, Mich.
Hulse, S. C......Ithaca, N. Y.
Humphreys, A. C., New York City
Hunt, Chas. W..New York City
Hunting, E. N...Pittsburg, Pa.
Hyde, C. G....Harrisburg, Pa.

Ives, A. S....Philadelphia, Pa.

Jacobs, C. M...New York City
Jacobs, R. H...New York City
Jaques, W. H., Little Boar's Head, N. H.
Johnson, A. L..St. Louis, Mo.
Johnson, L. J. Cambridge, Mass.
Johnstone, W. B. New York City
Just, G. A.....New York City

Kastl, A. E......Denver, Colo.
Kaufman, G....Brooklyn, N. Y.
Keith, H. C....Brooklyn, N. Y.
Keller, O. B...New York City
Kelley, W. D....Yonkers, N. Y.
Khuen, R......Ambridge, Pa.
Kimball, G. A...Boston, Mass.
King, Paul S...New York City
King, Wallace, Jr., New York City
Knap, E. D...Brooklyn, N. Y.
Knap, J. M.....New York City
Kolb, H. J....Brooklyn, N. Y.
Kummer, F. A..New York City

Landreth, O. H., Schenectady, N. Y.
Landreth, W. B..Albany, N. Y.
Lavis, F.......New York City
Leather, B. H..New York City
Lee, D. R...Middletown, N. Y.
Leffingwell, F. D., Montclair, N. J.
Leisen, T. A..Wilmington, Del.
Leonard, H. R. Philadelphia, Pa.
Lewis, F. H.....Staunton, Va.
Lindenthal, G..New York City
Lofland, H. F. Philadelphia, Pa.
Long, E. McL..New York City
Look, M. J......Clinton, Mass.
Loomis, Horace, Mt. Vernon, N. Y.
Loweth, C. F.....Chicago, Ill.
Lowinson, Oscar. New York City

MacCracken, G. G., New York City
Macdonald, H. P., Jersey City, N. J.
Machen, H. B..New York City
Macnab, G. T..New York City
McComb, C. O..Syracuse, N. Y.
McCulloch, R. A. New York City
McKay, J. E....New York City
McKenzie, T. H., Hartford, Conn.
McMinn, T. J..New York City
Madden, J. H..New York City
Manley, H.......Boston, Mass.
Mann, J. L....Hanover, N. H.
Marburg, Edgar, Philadelphia, Pa.
Marden, Henry H., New York City
Marple, W. M....Scranton, Pa.
Matcham, C. A..Allentown, Pa.
Mead, C. A., Upper Montclair, N. J.
Merriman, M., South Bethlehem, Pa.

Merriman, T...Paterson, N. J.
Merritt, D. S..Tarrytown, N. Y.
Miller, F.......New York City
Miller, H. A.....Boston, Mass.
Miller, H. C....New York City
Miller, R. P....New York City
Mills, C. M...Philadelphia, Pa.
Mitchell, S. P...Pittsburg, Pa.
Mixer, C. A.Rumford Falls, Me.
Modjeski, Ralph...Chicago, Ill.
Montfort, R.....Louisville, Ky.
Moore, C. H...Montclair, N. J.
Moore, W. H.New Haven, Conn.
Moran, D. E....New York City
Morrill, G. S....Boston, Mass.
Morrison, H. J..Clinton, Mass.
Moses, P. R....New York City
Moulton, Mace..New York City
Myers, C. H....New York City

Nelson, A. H....Pittsburg, Pa.
Nichols, C. H., New Haven, Conn.
Nichols, O. F..Brooklyn, N. Y.
Noble, Alfred...New York City
Noble, F. C...Brooklyn, N. Y.
North, Edward P., New York City

Ockerson, J. A..St. Louis, Mo.
Odell, F. S..Port Chester, N. Y.
Opdyke, S. B., Jr., New York City
Osgood, J. O......Jersey City
Ostrup, John C.New York City
Otagawa, M....New York City
Owen, James....Newark, N. J.
Oxholm, T. S., West New Brighton, N. Y.

Parker, A. M...New York City
Parker, C. J...New York City
Parmley, W. C..New York City
Parsons, G. W....Steelton, Pa.
Patch, W. W...New York City
Pegram, G. H..New York City
Pemoff, J. J....New York City
Peverley, R....New York City
Pistor, G. E. J..Newark, N. J.
Polk, W. A....New York City
Pollock, C. D..Brooklyn, N. Y.
Potter, Alexander, New York City
Pratt, W. A....New York City
Price, P. W.....Pittsburg, Pa.
Pruyn, P. W....Pittsburg, Pa.

Quinby, Edwin R., New York City
Quincy, C. F.....Chicago, Ill.

Read, R. L......Malden, Mass.
Reichmann, A. F..Chicago, Ill.
Reynders, J. V. W., Harrisburg, Pa.
Reynolds, J. O..New York City
Rice, G. S......New York City
Ridgway, R....New York City
Robinson, H. D.New York City
Rogge, J. C. L..New York City
Root, W. S.....New York City
Ropes, Horace..New York City
Rosenberg, F..Montclair, N. J.
Ryan, M. H....New York City

Safford, E. S...New York City
Sanborn, J. F..Brooklyn, N. Y.
Sanford, H. C..New York City
Sauer, A. F....Elizabeth, N. J.
Saunders, W. L.New York City
Schaub, J. W.....Chicago, Ill.
Schneider, C. C., Philadelphia, Pa.
Seaman, H. B..New York City
Sears, W. H...Katonah, N. Y.
Seaton, W., Jr..New York City
Sergeant, G., Jr.Brooklyn, N. Y.
Seurot, Paul....New York City
Shedd, Edward W., Providence, R. I.
Sherrerd, M. R..Newark, N. J.

Sickman, A. F. . Holyoke, Mass.
Simpson, G. F. . New York City
Skinner, F. W. . New York City
Sleeper, G. E. . . . Boston, Mass.
Slocum, C. M. Springfield, Mass.
Smith, Augustus. New York City
Smith, E. M. . . . . . Chicago, Ill.
Smith, J. W. . . . New York City
Smith, L. C. L., Long Island City, N. Y.
Smith, M. H. . . . New York City
Smith, Oberlin. Bridgeton, N. J.
Smith, W. F. . . . New York City
Snare, F. . . . . . . New York City
Snow, C. H. . . . . New York City
Snow, F. A. . . . Brookline, Mass.
Snow, J. P. . . . . . Boston, Mass.
Snyder, G. D. . . New York City
Soper, G. A. . . . . New York City
Spencer, W. T., New Haven, Conn.
Spooner, A. N. . New York City
Stanton, R. B. . . New York City
Stauffer, D. McN., New York City
Stearns, F. P. . . . Boston, Mass.
Stepath, C. W. . New York City
Stern, E. W. . . . New York City
Stewart, J. M. . . New York City
Stickney, G. F. . New York City
Stoddard, G. C. . New York City
Strobel, C. L. . . . . . Chicago, Ill.
Strong, M. R. . . . Passaic, N. J.
Stuart, F. L. . . . Baltimore, Md.
Swensson, Emil. . Pittsburg, Pa.
Swindells, J. S. Mt. Kisco, N. Y.

Taber, G. A. . . . New York City
Taft, J. R. . . . . . New York City
Talbot, A. N. . . . . . Urbana, Ill.
Taylor, C. F. . . . Boston, Mass.
Taylor, L. A. . . . Boston, Mass.
Taylor, S. A. . . . Pittsburg, Pa.
Thackray, G. E. Johnstown, Pa.
Theban, J. G. . . New York City
Thomas, G. E. . . New York City
Thomes, E. H. . New York City
Thompson, S. C. New York City
Thompson, S. E., Newton Highlands, Mass.
Thompson, A., Jr., Brooklyn, N. Y.
Thomson, G. H. New York City
Thomson, T. K. . New York City
Thorn, A. W. . . . Buffalo, N. Y.
Tighe, J. L. . . . . Holyoke, Mass.
Toch, Maximilian, New York City
Tribus, L. L. . . . New York City
Triest, W. G. . . . New York City
Tucker, H. F. . . . . Boston, Mass.
Tucker, L. W., Schenectady, N. Y.
Turner, D. L. . . New York City
Turner, E. K. . . . Boston, Mass.

Ulrich, D. . . . . . New York City

Van Buren, J. D., New Brighton, N. Y.
Van Buskirk, C. R., Brooklyn, N. Y.
Van Horne, J. G., New York City
Venable, W. M. . New York City
Vinton, T. M. . . New York City
Voynow, C. B. Philadelphia, Pa.
Vredenburgh, W., Jr., New York City

Waddell, J. A. L., Kansas City, Mo.
Wadsworth, J. E., New York City
Wagner, B. M. . Flatbush, N. Y.
Wagner, J. C. Philadelphia, Pa.
Walker, J. W. . . . Pittsburg, Pa.
Ward, C. R. . . . . New York City

Waterhouse, J. . New York City
Webster, W. R. Philadelphia, Pa.
Wegmann, E., White Plains, N. Y.
Wells, C. E. . . . . Clinton, Mass.
Welton, B. F. . . New York City
Wendt, Edwin F. Pittsburg, Pa.
Wheeler, D. M. Worcester, Mass.
Whipple, G. C. . New York City
Whiskeman, J. P., New York City
White, L. . . . . . Brooklyn, N. Y.
White, T. S. . Beaver Falls, Pa.
Wilcock, F. . . . Brooklyn, N. Y.
Wiley, W. H. . . . New York City
Wilkes, J. K., New Rochelle, N. Y.
Wilkins, W. G. . . Pittsburg, Pa.
Williams, G. S., Ann Arbor, Mich.
Williamson, S. B., New York City
Wilson, C. W. S., New Rochelle, N. Y.
Winsor, F. E. . . . Boston, Mass.
Wise, C. R. . . . . . Passaic, N. J.
Wolfel, P. . . . . . . Ambridge, Pa.
Woodard, S. H. Scarsdale, N. Y.
Worcester, J. R. . Boston, Mass.
Wortendyke, N. D., Jersey City, N. J.
Wright, J. B. . . New York City

York, H. W. . . . . New York City
Young, C. G. . . . New York City
Young, E. E. . . New York City.

SPECIAL COMMITTEE ON CONCRETE AND REINFORCED CONCRETE.

REPORT OF SUB-COMMITTEE ON PLAN AND SCOPE.

The sub-committee presents the following report for your consideration:

Reinforced concrete is comparatively new, but it has already become of great importance in engineering and architectural construction. The development of the Portland cement industry and the improvement of the product and the rapid extension of the use of concrete are among the noteworthy features of engineering progress in recent years. It is not too much to say that with the increased demand for permanence and better appearance in structures a very great extension of the use of reinforced concrete may be expected in the next few years. However, to ensure this development and to promote safe construction, a full knowledge of the properties and principles appertaining to reinforced concrete is needed. It is no reflection to say that our knowledge of reinforced concrete is imperfect. The very newness of this construction explains the paucity of information and diversity of opinions concerning it. But the lack of information and of experience in this work, and the carelessness or temerity of inexperienced or incompetent persons make the danger from accident and failure of structures very great. The importance of securing definite and complete knowledge of the principles underlying reinforced concrete construction before a serious accident caused by imperfect or improper construction injures the standing of reinforced concrete, is too apparent to need argument. Besides, the properties of concrete are not as regular or as well defined as those of such materials as structural steel, and the composite structure of steel and concrete may be expected to have a different action from that of the individual components. Recent investigations, too, seem not to confirm certain deductions considered by many to have been established. The need of a thorough and comprehensive investigation of the properties of reinforced concrete and of the principles underlying its design and construction is evident, and the sub-committee recommends that such an investigation be undertaken under the auspices of the joint committee and emphasizes the importance and the timeliness of such action to the engineering and constructional interests of the country.

It is true that many tests have been made on reinforced concrete, and much valuable information is in existence. However, some of the tests made show considerable difference in results and there is much diversity in their interpretation. These conflicting opinions extend to so many features and even to such fundamental principles that it seems best to begin with elementary matters and to get at the subject from the foundation up. As the investigation proceeds the conditions accompanying tests already made may be more accurately learned and trustworthy data of such tests collected and utilized, and the collation of this information, which is a work of some magnitude, may be made a valuable part of the undertaking. However, a large purpose of the investigation should be to establish principles independently of existing opinions, or of preconceived ideas, and the principal present use of existing available data will be to direct the nature and scope of the work and to avoid unwarranted assumptions.

The scope of the investigation will include both (*a*) the determination of fundamental principles and properties, and (*b*) the choice of the main general conditions and requirements controlling the more common designs and constructions. The above distinction is not intended to imply that the conditions and requirements of design and construction are not dependent upon principles and properties, but rather that, as the investigation proceeds, the results may be utilized without waiting for the completion of the work outlined, and that in the selection of the order of the work to be undertaken the choice should be such that items of probable immediate applicability will be taken up at first. This attention to the order of the tests is warranted by the desire of railroad and structural men to get facts upon which to base construction at as early a day as possible. At the same time it must be borne in mind that the bearing of facts and experiments upon important fundamental principles may not be recognized in advance and that care must be taken not to prejudge results nor to base conclusions on insufficient evidence. Besides, if this investigation is worth undertaking, the subject-matter is worthy of a comprehensive treatment, and the Joint Committee cannot afford to stand sponsor for a superficial investigation.

The sub-committee recognizes that the field for investigation is very large. In the outline of work which follows, no effort has been made to cover the whole field. As the work progresses, modifications and extensions will need to be made. The order of the outline given has no reference to the order in which the tests should be undertaken, nor is it expected that all these tests may be made the first year. Some of the experiments may give negative results, but this fact will not lessen the importance of making them. Some are included because they may help to uncover the field for further investigation.

As stated under Supervision and Administration the plan is to have the tests made in the laboratories of engineering schools, railroads, etc., which have facilities for the work and which upon consultation express willingness to co-operate. It is expected that much of the work will be done as thesis work by senior engineering students and that this will be greatly supplemented by volunteer investigators. Certain expenses will be defrayed from funds raised by the Committee on Ways and Means. Tests along special lines may require that special arrangements be made, and special apparatus may have to be provided. A committee to be known as the Committee on Tests will supervise the work, an inspector and other assistance will be furnished, and the management of the investigation will be as described under Supervision and Administration.

Uniformity and definiteness should be characteristic of the investigation. In the plan outlined, the selection of standard forms and proportions for test specimens, the description of the concrete and of the materials, and the general methods of testing are given in order that results of tests made at different places, at different times, and by different persons may be comparable. Some preliminary experimental work will be necessary before the standard test pieces can be finally fixed, and in any event some variations from the standard form and size of test pieces may have to be made. The properties and constants of the concrete used in the reinforced concrete test specimens will also, for purposes of comparison, be ascertained.

It is proposed by the plan to take up at the beginning the more simple constructions and the more fundamental principles and basic properties. Especial attention will be given to reinforced concrete beams, though columns and slabs will be taken up and plain concrete will be investigated to determine its properties and constants so far as they have a bearing upon reinforced concrete. Among the problems, variations, and determinations for reinforced concrete beams included in the scope of the work are the following: Amount of reinforcement; form, size and position of reinforcing bars; variety and consistency of concrete; carefulness of concrete making; repetition of load; manner of application of load; form of section; resistance to shearing; efficiency of devices and arrangements to resist shear; bond and anchorage; effect of age; general investigation of manner of failure and of the critical or controlling condition upon which the design of beams should be based. It will be seen that emphasis is placed on the stress-deformation relation, as this has so important a bearing on the action of reinforced concrete beams.

The scope of the work may be modified and extended as the development of the investigation warrants. Special problems coming up may need attention. It may be well in the report of the committee to formulate general regulations for the proper execution of work in reinforced concrete construction. It should be stated that the plan contemplates tests of reinforced concrete, using that term to mean a construction composed principally of concrete and having a small amount of metal so embedded as to take the principal tensile stresses and perhaps the secondary tensile and shearing stresses developed, but not to any great extent the compressive stresses, and does not include what may be termed steel-concrete meaning thereby steel structures encased in concrete and using the concrete principally for stiffening and protection.

The outline of the plan and scope which follows is arranged as follows:

SCOPE OF INVESTIGATION.

I. *Properties of Concrete.*—*A.* Compression; *B.* Tension; *C.* Shear; *D.* Flexure; *E.* Columns; *F.* Volumetric changes; *G.* Fire resisting properties.

II. *Properties of Reinforced Concrete under Simple Stresses.*—*A.* Compression; *B.* Tension; *C.* Initial Stresses; *D.* Bond and anchorage.

III. *Reinforced Concrete Beams.*—*A.* Simple flexure; *B.* Complex flexure; *C.* Restrained beams; *D.* Impact tests.

IV. *Reinforced Concrete Columns.*

V. *Reinforced Concrete Slabs.*

TESTING WORK.

I. *Materials and Mixing.*

II. *Test Pieces.*

III. *Testing.*

SUPERVISION AND ADMINISTRATION.

The full text of the plan and scope recommended is as follows:

SCOPE OF INVESTIGATION.

It shall be the purpose of the investigation to establish principles governing the action of the composite structure formed of steel and concrete and known as reinforced concrete, and to determine its properties and constants. The determination of the properties and constants of the concretes used will be made, so far as they have a bearing upon reinforced concrete.

I. PROPERTIES OF CONCRETE.

A. COMPRESSION.

Stress-deformation relation, crushing strength, and form of structure are to be determined on all the varieties of concrete used in the tests and for the three consistencies named hereafter. 8 by 16-in. cylinders are to be used for this. Tests of a few 6-in. cubes for the several varieties of concrete will be made to give opportunity for the comparison of strength of the concrete with that of other concretes.

1. General stress-deformation relation.
   Tests to be applied by a standard method which will be decided upon at a later time.
2. Time and repetition stress-deformation relations.
   (*a*) Comparison of relation when load is continuously applied and when load is released between successive applications of the increasing load. In this make an effort to determine the condition of the internal stresses in the concrete while load is being released and reapplied.
   (*b*) Effect of a number of repetitions of stress. Determine this effect and as far as possible the internal conditions and stresses for four different partial loads, using new test pieces for each partial load.
   (*c*) Rest effect. Determine the effect of rest upon a test piece partially loaded and then released.
   (*d*) Time effect. Determine the stress-deformation relation when load is left on test piece during say 3 days' time.
3. Effect of age upon stress-deformation relation.
   Use 7, 14, 28, 60 days and 6 months and 1 year.
4. Effect of applied stress upon setting properties.
   Get stress-deformation relation when loads are applied to test pieces during time of setting. Use two loads and two ages for loading.
5. Stress-deformation relation for abnormal concretes.
   Use concretes not having voids filled and having them overfilled and concretes which have not been compacted in making to determine the general effect of porosity. Use concretes which have set in abnormally hot and dry air to determine the effect of lack of moisture.

B. TENSION.

Stress-deformation relation and breaking strength are to be determined on all the varieties of concrete used in the tests and for the three consistencies named, using the test pieces to be described.

1. Continuous loading.
2. Progressively released loading.

C. SHEAR.

The scope of the shearing tests of concrete will be outlined at a later time.

D. FLEXURE.

Determine from a series of beam tests the principal properties of the concretes used.

E. COLUMNS.

This series will be coördinated with the tests of reinforced concrete columns.

F. VOLUMETRIC CHANGES.

1. Shrinkage and expansion changes in setting and nature and amount of stresses developed.
2. Temperature changes and stresses and coefficient of expansion.

G. FIRE RESISTING PROPERTIES.

This may not properly be included with the strength of concrete, but it may be considered desirable to have an investigation of the fire resisting properties of concrete under different conditions made.

II. PROPERTIES OF REINFORCED CONCRETE UNDER SIMPLE STRESSES.

A. COMPRESSION.

Stress-deformation relation, change in cross-section, and crushing strength are to be determined on all the varieties of concrete used for the three consistencies named, using the size of cylinder given for compression tests.

(*a*) Longitudinal reinforcement.

Use metal equal to 1% of the area of the test piece.

(*b*) Hooped reinforcement.

Hoops are to be 6 in. outside diameter, and are to be encased in concrete. Use two and three hoops of $\frac{3}{16}$-in. metal, varying the total width up to one-third of the height of test specimen. Also use hoops made of round rods.

B. TENSION.

Stress-deformation relation and breaking strength are to be determined on all the varieties of concrete used in the tests and for the three consistencies named, using in general the test piece to be described.

1. General stress-deformation relation.

   Use three percentages of metal with both plain and deformed bars.
2. Effect of adhesion and grip of the concrete upon the elastic properties of steel, both before and after cracks appear in the concrete. Use a special form of test piece with two different amounts of encasing concrete.
3. Effect of initial stresses in both concrete and steel. This is to be taken in connection with the tests on initial stresses.

C. INITIAL STRESSES.

Effect of volumetric changes (setting and temperature). Test piece and method to be decided upon later. Use one kind of aggregate, two mixtures and three consistencies. Determine relations for concretes (1) set in air and (2) set in water.

D. BOND AND ANCHORAGE.

The term bond will be used to include the resistance to the slipping of a bar in concrete due to (1) adhesive resistance along the surface of the bar, (2) frictional resistance resulting from the shrinkage and grip of the concrete on the bar, and (3) resistance due to irregularities or variation in shape of bar commonly known as deformed bars.

1. Plain bars.
    - (*a*) Effect of consistency of concrete. Use three proportions of water, and two mixtures of concrete.
    - (*b*) Effect of variety of concrete. Use the mixtures of concrete used in the reinforced concrete beams.
    - (*c*) Effect of condition of surface: scale, rust, oil, paint, etc.
2. Effect of shape of bar.
    - (*a*) Plain bars, round, square, flat (2).
    - (*b*) Deformed bars. Use the various patented forms of bar.
3. Anchorage.
    - (*a*) Bars with enlarged ends.
    - (*b*) Bars with ends bent.
    - (*c*) Bars connected to anchorage pins or plates.
4. Relative value of surface adhesive resistance and of grip. Make tests (*a*) for surface adhesive resistance, and (*b*) for combined friction and surface adhesion, making measurements of the shrinkage and swelling with different methods of storage (*i. e.*, immersed in water, stored in moist air, and stored in dry air).
5. Permanence of bond.
    - (*a*) Effect of chemical action on bond, including use of salt water.
    - (*b*) Effect of vibratory motion or unsteady loading.
    - (*c*) Effect of repetition of loading.
    - (*d*) Effect of impact.

III. REINFORCED CONCRETE BEAMS.

A. SIMPLE FLEXURE.

Simple flexure is here used to include flexural action which makes horizontal tensile and compressive stresses the controlling factors, as found in beams in which the dimensions and methods of loading do not necessitate special or unusual provision to resist shearing stresses and secondary or diagonal tensile and compressive stresses.

The general phenomena of the flexure will be observed as the load is applied. Observations will be made to determine the horizontal deformations, the deflection, position of neutral axis, time of appearanee, nature, and growth of cracks, and general conditions for loads up to the maximum load and in part of the beams for loads up to the ultimate load and final failure; also the amount of the maximum load and conditions governing it. Any other condition or appearance having a bearing upon the establishment of laws governing maximum load, allowable load, and permanence of structure under load or when subject to loading will be noted. For the principal series all the varieties of aggregate and all the mixtures of concrete will be used

1. Effect of amount of reinforcement. Use varying amounts of metal, ranging by say ¼% of area of cross-section from perhaps ¾% to an upper limit which will develop full compressive strength of the concrete and in some cases to an even larger amount. Use all the mixtures of concrete. Use plain steel bars of low (say 30 000 to 35 000 lb. per sq. in. elastic limit), medium (say 45 000 lb. per sq. in.), and high (say 60 000 lb. per sq. in.).
2. Effect of elastic limit of metal. This is included in the foregoing.
3. Effect of form, size, and position of reinforcing bar. Use two percentages of metal. Use best mixture of concrete and the wet consistency.
    - (*a*) Deformed bars.
    - (*b*) Round, square, and flat bars.
    - (*c*) Bars in two layers.
4. Time tests, repetitions, and set.
    - (*a*) Comparison of relation when load is continuously applied and when load is released between successive applications of the increasing load. Make an effort to determine the conditions of stress in the concrete while load is being released and applied.
    - (*b*) Effect of a number of repetitions of load. Determine this effect, and as far as possible the internal conditions and stresses for four different partial loads, then continue the loading to failure, using new test pieces for each partial load.
    - (*c*) Effect of rest upon a beam which has been loaded within the elastic limit of the steel and the load released. Use three partial loadings.
    - (*d*) Effect of time upon deformation and deflection and set when load is left on beam for say three days. Use three partial loads.
5. Effect of uniform loading. Test beams with points of application of loads sufficiently numerous to approximate uniform loading and compare with the results of standard loading.

6. Tee sections, trapezoidal and other forms. The position of neutral axis, the limiting percentages of steel to develop crushing strength of concrete, and other properties will be determined for such mixtures and combinations as seem practicable after the work of the year has been further developed.
7. Composite beams. Effect of mixtures varying in richness or composition in the upper and lower layer and of the making of upper layer at a later time as when a floor slab is placed on a girder. This work is to be outlined at a later date.
8. Effect of size. Beams of different dimensions but having the same method and percentage of reinforcement will be tested to find whether results with the standard size used are applicable to beams having other dimensions.

B. COMPLEX FLEXURE.

Complex flexure is here used to cover flexural action requiring the consideration and determination of internal stresses and deformations other than the horizontal tensile and compressive stresses commonly considered in beam action. The work will include an investigation of the needs and the effectiveness of various devices and arrangements for strengthening beams against shearing action and secondary or diagonal tensile and compressive stresses.

In addition to the observations and determinations named for the tests in Simple Flexure, such observations and measurements of deformations, cracks, and other conditions will be made as seem to have a bearing upon the determination of these shearing and secondary stresses and upon the effectiveness of provisions for resisting them. The detailed arrangements for these tests will require considerable thought and planning. One method will involve a variation in the point of application of the loads, changing from the middle toward the two ends, to vary the relative value of shear and horizontal stresses. For some of the arrangements beams of different lengths may be used. In general, the limiting amount of reinforcement will be used.

1. Effect of bending reinforcing bars into an inclined or diagonal position. Use both plain and deformed bars. Find effect of unsymmetrical loading. Use some weaker concretes as well to determine law.
2. Effect of stirrups and similar devices.
3. Effect of anchorage. This will include bent ends, enlarged ends, and ends tied to anchorage devices.
4. Effect of winged bars. This includes the so-called trussed bars.
5. Effect of deformed bars used in horizontal position. This series will be combined with the similar series of Simple Flexure.
6. Variations of some of the series above with tee-shaped and other sections, including putting reinforcement in two layers.

7. Effect of uniform loading. Tests beams with the points of application of the load sufficiently numerous to approximate uniform loading and compare with the results of standard loading.

C. Restrained Beams.

The work in this division will be outlined at a later time.

D. Impact Tests.

The work in this division will be outlined at a later time.

IV. Reinforced Concrete Columns.

The term column will here be used to mean a piece more than three diameters in length which is subject to compression in the direction of its length. The tests are intended to determine the principal deformations, the behavior of the column as loading progresses, the manner of failure, the maximum and ultimate loads, the tendency to crushing at the ends and the effect of variations in the end bearing, the relation of strength to the ratio of least diameter and length, and the effect of eccentricity of loading. The details of the series will be outlined at a later date.

1. Effect of longitudinal reinforcement.
2. Effect of hooped reinforcement.
3. Effect of combined reinforcement.

V. Reinforced Concrete Slabs.

The slabs are to be tested supported at four edges and fixed at four edges. It is probable that special apparatus will have to be constructed for these tests. Variations in size and thickness of slab and in method and amount of reinforcement will be made. This work will be outlined at a later date.

TESTING WORK.

I. Materials and Mixing.

1. *Cement.* The cement will be American Portland cement of the best grade used on concrete construction. Particular attention will be given to uniformity of quality to ensure a basis for comparison of results. Tests will be made according to the standard method of the American Society of Civil Engineers and the American Society for Testing Materials. The description and requirements for materials and mixing will be made more definite and complete when the scope of the test is more fully settled and when more is known concerning what materials are available.

2. *Sand.* The sand will be sharp torpedo sand with grains well graded in size, containing not more than 30% voids and not more than 5% of clay.
3. *Aggregate.* In the tests to determine general properties of concrete and reinforced concrete several forms of aggregate will be used, broken limestone, broken trap rock, gravel and cinders. For tests to determine special relations and effects only broken stone will be used. In order to secure a more uniform material, crusher dust will be excluded from broken stone. The stone will be screened through a 1-in. screen and over a ¼-in. screen. In order to get more definite proportions the gravel will be screened in the same way.
4. *Mixtures.* In general a balanced mixture of mortar and aggregate will be used, the volume of mortar being from 10% to 20% more than the voids of the aggregate. Two grades of mortar will be used, rich and medium. This will make for the broken stone something like 1-2-4 and 1-3-6 concretes.
5. *Mixing.* The specifications of the American Railway Engineering and Maintenance of Way Association will be used to secure thorough mixing. Considerable preliminary experimental study will be needed before framing full specifications for mixing and packing in the moulds in order to secure as nearly as possible the same results at different times, at different places, and by different persons, and the percentage of variation thereby resulting will need to be determined.
6. *Consistency.* An amount of water to make a wet rather than a dry concrete will be used. In some tests three consistencies will be used—moderately dry, moderately wet, and very wet.
7. *Tamping.*—The amount and manner of tamping is to be gauged by the consistency of the concrete, but an effort will be made to secure density and uniformity in the concrete.
8. *Storage.* In general the test pieces will be moistened for three or four days and then be stored exposed to ordinary atmospheric conditions in rooms having a temperature of 65° to 75° Fahr. during the time of year when artificial heat is needed. The conditions of abnormally dry atmosphere are to be avoided. A special series will be used to determine the effect of dry and hot atmospheric conditions.

II. TEST PIECES.

In fixing the dimensions of test pieces, a size is desired which is large enough to minimize so far as possible the effect of uncontrolled or unseen irregularities of construction and setting, and to make the measurement of deformations and other changes large enough to be accurately observed. At the same time the limits of the facilities of laboratories have been considered. Probably after principles have become better known, a few principal series should be repeated on a large scale. In addition to the test pieces named, it is considered highly desirable in order to ensure reliable results that at each of the laboratories where work is done several practice test pieces be made and that these be used in familiarizing those assisting in the work with the needs and difficulties of the tests but be not considered as counting in the final results. It is recognized that some variations from the form and size of test pieces here described may be necessary.

1. COMPRESSION.—The standard compression test piece will be a cylinder 8 in. in diameter and 16 in. long. A facing of mortar ¼ in. thick will be put at the top and the bottom. Cubes of 6-in. edge will be used to enable a comparison to be made with concretes used elsewhere. Preliminary tests will be made on cylinders of different lengths to determine whether the length of the standard cylinder should be modified and whether the quality of the concrete obtained corresponds to that made in the reinforced beam and column test piece.

2. TENSION.—The standard tension test piece will be a cylinder 8 in. in diameter and 32 in. long. 3 in. at each end will be made of mortar and eight or twelve bolts will be embedded in this, connecting the test piece at either end with a stiff head in which a pulling bar with spherical bearing is set in a manner similar to the method used at the University of Illinois.

   For determining the effect of concrete upon the elastic properties of steel, a bar will be encased for part of its length in a concrete cylinder and the ends will project sufficiently to permit attachment of the extensometers and to permit the bar to be held in the testing machine. The cylinders will be of two or three sizes, perhaps 3, 4, and 6 in. diameter.

3. BOND AND ANCHORAGE.—For determining surface adhesive resistance, the bar will be laid on a block of concrete 6 in. long with one face embedded ⅛ in., and will project at one end sufficiently to allow the load to be applied. The block of concrete will be of such size and shape and have such bearing as to permit a direct pull on the bar.

   For the general tests for bond the bars will be encased in a cylinder 4 in. in diameter and 6 in. long, and one end will be flush with the end of the cylinder. Special forms of piece will be used for tests of anchorage.

4. BEAMS.—The standard beam test piece will be 8 in. wide, 11 in. deep, and 13 ft. long. The center of the reinforcing bars will be 10 in. below the top of the beam, except where they are bent

or inclined upward for a special purpose. The forms will be firmly braced to secure uniform cross-section. During construction the concrete will be well spaded along the side forms to secure a smooth surface. The top will be coated with a thin layer of mortar to remove irregularities. For beams of other than standard size special plans will be made.

5. COLUMNS.—The size and form of column will be decided upon at a later date. 10 by 10-in. section and a length of 5, 10, 15 and 20 diameters is suggested. Larger sections will be used for special tests. The arrangement and distribution of the reinforcement will require further planning.
6. SLABS.—The outline for the form, size, and manner of reinforced concrete slabs will require further planning.
7. MISCELLANEOUS TEST PIECES.—The forms of test pieces for shear tests and for volumetric and other tests will be outlined when the work has been more fully developed.

III. TESTING.

In order that uniformity may be secured and the results of tests made in different laboratories may be known to be comparable, it is important that common regulations be adopted. The making of these will involve consultation and discussion. What is here outlined is subject to change.

1. COMPRESSION.—Concentric loading is of prime importance in compression tests. Spherical bearing block, roller bearings, or hydraulic bearing block should be used. A thin layer of plaster of paris will be placed between test piece and bearing plate and allowed to set under a light load. The extensometer gauge length will be 12 in. The arrangement of extensometer will be such that flexural action in the test piece will be nullified as far as seems possible.
2. TENSION.—The arrangement for testing tension pieces will be such as to give a direct pull and avoid flexural stresses in the test piece. In general the extensometer gauge length will be 24 in. The arrangement of the contact points and gauge bars of the extensometer will be such that the effect of flexural action in the test piece will be slight. Bars for use in test for effect of concrete encasing upon elastic properties of steel will first have the modulus of elasticity of the naked steel determined.
3. BEAMS.—The method of applying the load is an important consideration. One great defect found in many tests of reinforced concrete beams is the indefiniteness of the distribution of the load, and in some tests the loading used must have

acted to strengthen the beams. As used in structures, reinforced concrete beams are subject to both uniform and concentrated loads, and tests should cover both conditions. The general standard loading selected has the load applied equally at two points, the one-third points of the span. This loading does not differ greatly in maximum bending moment and in shear at the end from the conditions for uniform loading and has the advantage for the measurement of deformations that the moment except for that due to the dead load is equal at all points between the two load points. Series of tests will be made with the load applied equally at points sufficiently numerous to approximate to the conditions of uniform loading and also series with concentrated loading. The beam supports and the method of applying the load must give good bearing and allow adjustment for warped condition of beams and for free changes in distances between these points. In general the extensometer gauge length will be about one-third of the span length. The general standard for test span will be 12 ft. Deflections will be observed for the middle of the span length.

4. MISCELLANEOUS TESTS.—The method of testing columns and slabs and of testing for shearing resistance is reserved for future consideration.

5. METHOD OF APPLYING LOADS.—Different methods of applying loads will give quite different results. The effect of continuous, progressive loading, loading released after each observation, and progressive loading with the load released two or three times should be investigated. The choice of a standard method of applying the load should be postponed until preliminary tests have been made, as the decision of this point is a matter of importance.

6. DUPLICATION OF TESTS AND NUMBER OF TEST PIECES.—In general one more test piece will be made than required for the series, the extra one to be used in case of accident to another or of marked disagreement among the others. For compression, tension, shear and bond, five test pieces will be made and four will constitute a series. For beams, slabs and columns, three test pieces will be made and two will constitute a series. Some of the more important series of tests will be duplicated, the work being done in two laboratories.

7. AGE FOR TESTING.—In general, the standard age for testing will be 60 days after the test piece is made.

The number of mixtures of concrete to be used for any line of investigation is not always fully stated in the outline. Further attention will be given to this.

SUPERVISION AND ADMINISTRATION.

It is the plan to have these tests made in the laboratories of engineering schools, railroads, etc., which have facilities for the work, and which upon consultation express willingness to co-operate. It is expected that much of the work will be done as thesis work by senior engineering students, and that this will be greatly supplemented by volunteer investigators. The expense of materials and transportation, and of extra labor employed in making, handling, and testing the test pieces will be defrayed from funds raised by the Committee on Ways and Means.

The general conduct of the investigation will be in charge of a committee of five members to be called the Committee on Tests. In the prosecution of the work it will be very necessary to know conditions and results and to insure uniformity of methods and correlation of work. This will involve considerable correspondence, travel, and supervision, and the committee should have suitable and sufficient assistance. Inspectors will be employed who will be under direction of the Committee in Charge of Tests. They will aid in arranging for tests, in doing testing work, and in putting results in permanent form, and will consult and confer with the laboratories doing work. The inspectors will be able to be of much service in formulating blanks, collecting existing data, and generally assisting in the investigation. Other help will be employed as needed.

The results of tests made at any institution may be used by the institution, but they shall not be published by students. Individuals connected with the laboratories may publish results, with the consent of the Joint Committee on Reinforced Concrete.

The above outline of plan and scope of the investigation is somewhat tentative and is necessarily incomplete and in some respects indefinite. When it is known more fully what work will be undertaken, full plans and regulations may be made. It may not be feasible to carry out all the work outlined during the first year, and it is not unlikely that developments in the investigation will show the necessity of repetition and modification in succeeding years.

The sub-committee realizes the magnitude of the task proposed, but it desires to emphasize the importance of the undertaking and to express its belief that the results of such an investigation carried out in a thorough and comprehensive way would be of great value to the engineering world.

A. N. TALBOT,
W. K. HATT,
J. W. SCHAUB,
Committee on Plan and Scope.

ANNOUNCEMENTS.

The House of the Society is open from 9 A. M. to 10 P. M. every day, except Sundays, Fourth of July, Thanksgiving Day and Christmas Day.

MEETINGS.

Wednesday, March 1st, 1905.—8.30 P. M.—A regular business meeting will be held. Ballots for membership will be canvassed, and a paper entitled "Technical Methods of River Improvement, as Developed on the Missouri River, by the General Government, from 1876 to 1903," by S. Waters Fox, M. Am. Soc. C. E., will be presented for discussion.

This paper was printed in *Proceedings* for January, 1905.

Wednesday, March 15th, 1905.—8.30 P. M.—At this meeting a paper entitled "The Compensating Works of the Lake Superior Power Company," by G. F. Stickney, Assoc. M. Am. Soc. C. E., will be presented for discussion.

This paper is printed in this number of *Proceedings*.

ANNUAL CONVENTION.

The Thirty-Seventh Annual Convention will be held in Cleveland, Ohio, June 20th-23d, 1905. The following Committees have been appointed to take charge of the arrangements.

COMMITTEE OF THE BOARD OF DIRECTION:

Alfred Craven, *Chairman;*
N. P. Lewis,
W. J. Wilgus,
Charles S. Gowen,
Chas. Warren Hunt.

LOCAL COMMITTEE:

A. Mordecai, *Chairman;*

Wm. J. Carter,
Harry Fuller,
E. A. Handy,
A. M. Johnston,
M. W. Kingsley,
J. Francis Le Baron,
F. C. Osborn,
W. P. Rice,
J. Ritchie,
W. H. Searles,
S. T. Wellman,
C. H. Wright.

PRIVILEGES OF LOCAL SOCIETIES EXTENDED TO MEMBERS OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS.

The Boston Society of Civil Engineers will welcome any member of the American Society of Civil Engineers at its library and reading room, 517 Tremont Temple, Boston, which is open on week days from 9 A. M. to 5 P. M. Members will also be welcome at the meetings, which are held in the same building, on the evenings of the fourth Wednesday in January, and the third Wednesdays of other months, except July and August.

The rooms of **The St. Louis Engineers' Club** are in the business center of St. Louis, and visiting engineers are cordially invited to use them for mail, telephone service, information, etc.

The courtesies of **The Engineers' Society of Western Pennsylvania** have been extended to members of the American Society of Civil Engineers. The rooms of the Society, 410 Penn Ave., Pittsburg, Pa., are open at all times, and meetings are held as follows, except during July and August. REGULAR SECTION, Third Tuesdays; CHEMICAL SECTION, Thursdays following third Tuesdays; MECHANICAL SECTION, First Tuesdays; STRUCTURAL SECTION, Fourth Tuesdays.

The Western Society of Engineers, Monadnock Block, Chicago, Ill., tenders to members of this Society the use of its rooms and facilities, together with the good offices of its Secretary and of a special committee appointed for that purpose.

The Civil Engineers' Club of Cleveland, Ohio, invites members of this Society to make use of the Club rooms, at any time when in Cleveland. Cards will be furnished on application to the Secretary, Mr. J. C. Beardsley.

The Engineers' Club of Central Pennsylvania has established new quarters at the corner of Second and Walnut Streets, Harrisburg, Pa., and desires to extend the courtesies of the Club to visiting members of the American Society of Civil Engineers.

SEARCHES IN THE LIBRARY.

In January, 1902, the Secretary was authorized to make searches in the Library, upon request, and to charge therefor the actual cost to the Society for the extra work required. Since that time many such searches have been made, and bibliographies and other information on special subjects furnished.

The resulting satisfaction, to the members who have made use of the resources of the Society in this manner, has been expressed frequently, and leaves little doubt that, if it were generally known to the membership that such work would be undertaken, many would avail themselves of it.

The cost is trifling, compared with the value of the time of an

engineer who looks up such matters himself, and the work can be performed quite as well, and much more quickly, by persons familiar with the Library.

Copies of all lists of references are filed, so that in many cases it is only necessary to make a typewritten copy, which reduces the cost of searches to a minimum.

In asking that such work be undertaken, members should specify clearly the subject to be covered, and whether references to general books only are desired, or whether a complete bibliography, involving search through periodical literature, is desired.

INTERNATIONAL ENGINEERING CONGRESS PUBLICATIONS.

The first two volumes of the Proceedings of the International Engineering Congress are nearly ready for distribution to all Members elected prior to December 31st, 1904. There will be six volumes in all. Members have been notified that they would receive these volumes (issued as Parts A, B, C, D, E and F of Vol. LIV of *Transactions*) and asked whether they wished them bound in one of the Standard Bindings. A number of Members who have their Volumes bound regularly have not responded, and consequently will receive these volumes in paper covers, unless an order is received at once for their binding. It is urged that all who care to have these volumes bound, and who have not already done so, send in an order for such binding immediately.

DONATIONS.*

* Unless otherwise specified, books in this list have been donated by the publisher.

LOCKS AND HARDWARE.

By Henry R. Towne. Leather, 7 x 5 in., illus., 1117 pp. New York, John Wiley & Sons. London, Chapman & Hall, Limited, 1904. $3.

The preface states that this work is a combined handbook of technical information and ready-reference catalogue of locks and hardware to meet the needs of the architectural profession. The author's experience of thirty years as a manufacturer, it is stated, is a justification for attempting this volume. Preceded by a glossary of technical terms, the arrangement of the book is as follows: Part I, Narrative and Historical; II, Mechanics of Hardware; III, Art Metal Work and Ornament; IV, Locks and Latches; V, Locks in Sets; VI, Plain Hardware; VII, Hardware Groups; VIII, Cabinet Hardware; IX, Specifications, etc.; X, Miscellaneous Information. There is an alphabetical index of ten pages, and a numerical index of fourteen pages. Ornamental hardware is also arranged, alphabetically, by designs and by schools in the section devoted to that subject.

ELEMENTS OF MECHANISM.

By Peter Schwamb and Allyne L. Merrill. Cloth, 9 x 6 in., illus., 6+264 pp. New York, John Wiley & Sons. London, Chapman & Hall, Limited, 1904. $3.

The preface states, that the main subject-matter of this work was written during 1885, as a basis for instruction in mechanism at the Massachusetts Institute of Technology. The notes have been revised and such changes and additions made as experience has proved advisable. The authors have endeavored to make the manner of presenting the subject, systematic, clear and practical. Such available material has been used as appeared best to accomplish the object desired and very little claim is made as to its originality. There is an index of ten pages.

RAILWAY RIGHT-OF-WAY SURVEYING.

By Albert I. Frye, M. Am. Soc. C. E. Cloth, 9 x 6 in., 9+45 pp. New York, *Engineering News* Publishing Company, 1904.

It is stated in the preface, that this book outlines a modern system of right-of-way surveying, leveling and mapping. Though the system as a whole applies particularly to railroads, the "adjustment diagram" will be found useful in the special adjustment of streets, canals, highways and old boundary lines. This method of survey must not be confused with the common one of using the outside head of rail as a base line for locating the various structural features. Vast sums of money have been spent for such surveys, leaving no permanent field reference to lines run and recording sets of maps without any measurements whatever. The system here presented, it is stated, gives the most accurate, available and permanent records, and reduces the important field measurements and office data to rectangular coordinates referred to an established center line. The Journal and Ledger system is a definite plan of rearranging and tabulating data as obtained.

THE ARCHITECTS' DIRECTORY AND SPECIFICATION INDEX, 1904-05.

Containing a Complete List of the Architects in the United States and Canada. Edition 6. Cloth, 10 x 7 in. New York, William T. Comstock, 1904. $2 net.

This edition has several new features, such as the number of architectural firms in each state, and the total number for the United States and for Canada, the latest schedule of architect's charges, and also a list of Landscape Architects and one of Naval Architects. It is stated that a very complete list of architectural societies is presented, with the names of the principal officers and their location, and in the list of architects, abbreviations are given against each name indicating membership. The name and location of architectural schools and periodicals are also given. Under the heading Specification Index are classified the more important names and addresses of manufacturers and dealers in building materials and appliances.

AIR-BRAKE TESTS.

Compiled and Published by the Westinghouse Air Brake Company; in Connection with its Exhibit of Braking Appliances at the Louisiana Purchase Exposition. Leather, 7 x 5 in., illus., 323 pp. Wilmerding, Pa., Westinghouse Air Brake Company, 1904.

This work contains the history of the brake from the beginning of its use on the old "Diligence" more than 250 years ago. But the primary purpose, it is stated, is to present in a comprehensive way and at the same time in condensed form, the data that has resulted from the most significant and valuable of the practical tests made under conditions found in actual service, with such comment as the wider experience of the day seems to justify. The contents are: The Growth of Car Braking; Galton-Westinghouse Tests; Paris and Lyons Railway Tests; The Burlington Trials (C., B. & Q. R. R.); Westinghouse Freight Train Trials; The Karner Trials (N. Y. C. & H. R. R. R.); Sang Hollow Tests (P. R. R.); Shiproad Tests (P. R. R.); Nashville Locomotive Brake Tests; Absecon Tests (P. R. R.); Atsion Tests (C. R. R. of N. J.)

A TEXT-BOOK ON ROOFS AND BRIDGES.

Part I, Stresses in Simple Trusses. By Mansfield Merriman, M. Am. Soc. C. E., and Henry S. Jacoby, Assoc. Am. Soc. C. E. Edition 6. Cloth, 9 x 6 in., 10+316 pp., illus. New York, John Wiley & Sons; London, Chapman & Hall, Limited, 1905. $2.50.

This volume has been rewritten and reset to properly record the changes that have taken place, in the science and art of the construction of simple bridges, since 1888, when the first edition was published; and to give the student the latest point of view. The preface states that many historical and critical notes have been introduced, showing the best modern practice. The former classification for bridges has been abandoned and one involving loads has been introduced, the dead load stresses, the live load stresses, the stresses due to wind and other causes are treated in separate chapters for the common forms of simple trusses. The modern long span bridges are treated in Chapter V, more than half the material is entirely new, as is all of that given in Chapter VI, which treats of portal and sway bracing, bridge members and floors and plate girders. Chapter VII treats of deflections, and the demonstration that the economic depth of a truss is closely tho one which gives greatest stiffness, the authors believe to be new. Cranes, bents, towers, viaducts and other miscellaneous structures are discussed in Chapter VIII. There is an index of nearly four pages.

Gifts have also been received from the following:

Allen, Kenneth. 1 pam.
Am. Ry. Assoc. 1 pam.
Am. Soc. Mech. Engrs. 1 pam.
Boston—Public Lib. 1 vol.
Cal.—Dept. of Highways. 1 pam.
Cambridge—Water Board. 1 vol.
Case School of Applied Sci. 1 vol.
Coast and Geodetic Surv. 1 pam.
Colo.—Coll. Agri. Exper. Station. 1 pam.
Conn.—State Board of Health. 1 bd. vol.
Dudley, C. B. 1 pam.
Fitch, G. D. 1 vol.
Ind.—Board of Health. 1 bd. vol.
Inst. of Civ. Engrs. 2 vols.
Inst. of Min. & Metallurgy. 1 bd. vol.
Interborough Rapid Transit Co. 1 bd. vol.
Isthmian Canal Comm. 2 pam.
Koninklijk Inst. van Ingenieurs. 1 pam.
Linders, Olaf. 1 pam.
Mass.—Harbor & Land Commrs. 1 bd. vol.
Mass. Inst. of Tech. 1 pam.
Mexican Central Ry. Co. Ltd. 1 pam.
Met. Ry. Co. 1 pam.
Mich.—Geol. Surv. 1 bd. vol.
National Arts Club. 1 pam.
National Assoc. of Mfgrs. of Sand-Lime Products. 1 pam.
N. Y., R. R. Branch, Y. M. C. A. 1 vol.
N. Y.—State Engr. & Surv. 1 vol.
Oberlin Coll. 1 pam.
Ontario—Bureau of Mines. 1 bd. vol.
Ontario Land Surv. 1 pam.
Ontario—Provincial Board of Health. 1 pam.
Oswego Historical Soc. 1 vol.
Plainfield Pub. Lib. 1 pam.
Pontzen, Ernest. 1 pam.
Poor's R. R. Manual Co. 2 pam.
Ry. Signal Assoc. 1 vol.
Rhode Island—State Board of Health. 1 bd. vol.
Richardson, H. B. 1 pam.
Rugby Eng. Soc. 1 bd. vol.
St. Louis and San Francisco R. R. Co. 1 pam.
Schmidt, M. E. 1 pam.
Sherwood, F. A. 1 vol.
South Eastern Ry. Co. 1 pam.
Troy—City Engr. 1 bd. vol.
U. S. Commr. of Navigation. 1 bd. vol.
U. S. Engrs. School of Application. 1 pam.
U. S. Forestry, Bureau of. 1 pam.
U. S. Geol. Surv. 1 vol., 3 pam.
U. S. Interstate Commerce Comm. 1 bd. vol.
U. S. Lib. and Naval War Records. 1 pam.
U. S. Office of Exper. Stations. 1 pam.
U. S. Office of Pub. Road Inquiries. 1 pam.
U. S. War Dept. 17 Specif.
Univ. of Ill. 1 pam.
Univ. of Mich. 1 pam.
Univ. of Pa. 1 vol.
U. S.—Patent Office. 1 vol.
Unknown. 1 pam.
Waddell, J. A. L. 2 pam.
Watuppa Water Board. 1 pam.
Wyoming—State Geologist. 1 pam.

BY PURCHASE.

The Purification of Sewage. Being a Brief Account of the Scientific Principles of Sewage Purification and their Practical Application. By Sidney Barwise. Edition 2. New York, D. Van Nostrand Company, 1904.

Alternating Current Engineering; Practically Treated. By E. B. Raymond. New York, D. Van Nostrand Company, 1904.

War-Ships; A Text-Book on the Construction, Protection, Stability, Turning, etc., of War Vessels. By Edward L. Attwood. New York, Longmans, Green & Company, 1904.

Cours de Navigation Intérieure. Vol. III. Canaux. Par F. B. de Mas. Paris, Ch. Béranger, 1904.

A Treatise on Civil Engineering; By W. M. Patton. Edition 2. New York, John Wiley & Sons. London, Chapman & Hall, Limited, 1903.

The Materials of Construction; a Treatise for Engineers on the Strength of Engineering Materials. By J. B. Johnson. Edition 4, revised and enlarged. New York, John Wiley & Sons. London, Chapman & Hall, Limited, 1904.

Verdampfen, Kondensieren und Kühlen; Erklärungen, Formeln und Tabellen für den Praktischen Gebrauch. Von E. Hausbrand. Edition 3, revised. Berlin, Julius Springer, 1904.

Electric Smelting and Refining; the Extraction and Treatment of Metals by Means of the Electric Current. By W. Borchers. Second English edition. London, Charles Griffin & Company, Limited, 1904.

SUMMARY OF ACCESSIONS.

January 11th to February 7th, 1905.

Donations (including 4 duplicates)	90
By purchase	8
Total	98

MEMBERSHIP.

ADDITIONS.

HONORARY MEMBERS.

	Date of Membership.
Gorsuch, Robert Bennett. Apartado del Correo 226, City of Mexico, Mexico	Jan. 9, 1905
White, ***Sir*** **William Henry.** Cedarcroft, Bristol Gardens, Putney Heath, S. W., London, England	Dec. 16, 1904

MEMBERS.

Allen, Henry Clayton. Special Deputy State Engr., DeGraaf Bldg., Albany (Res., 206 Delaware St., Syracuse), N. Y.	Assoc. M. M.	July 1, 1891 Jan. 3, 1905
Burns, Clinton Sumner. Civ., Hydr. and San. Engr. (Burns & McDonnell), 509 Dwight Bldg., Kansas City, Mo	Assoc. M. M.	Feb. 1, 1899 Jan. 3, 1905
Christy, George Lewis. 128 West 42d St., New York City	Jun. Assoc. M. M.	June 6, 1893 Nov. 4, 1896 Jan. 31, 1905
Clarke, Ernest Wilder. Res. Engr., Water-Works and Sewers, Isthmian Canal Comm., Cristobal, Canal Zone, Panama		Jan. 4, 1905
Conkling, Cloud Clifford. Chf. Civ. Engr., Lackawanna Steel Co., 385 Richmond Ave., Buffalo, N. Y.		Jan. 4, 1905
Cosby, Spencer. Capt., Corps of Engrs., U. S. A., Manila, Philippine Islands		Oct. 5, 1904
Crozier, William. Brig.-Gen., Chf. of Ordnance, U. S. A., War Dept., Washington, D. C.		Feb. 1, 1905
Easby, William, Jr. Asst. Prof. of Civ. Eng., College Hall, Univ. of Pennsylvania, Philadelphia, Pa.		Jan. 4, 1905
Floesch, Jacob Martin. Chf. Engr., B. R. & P. Ry. Co., Rochester, N. Y.		Jan. 4, 1905
Ford, Porter Dwight. Cons. and Constr. Engr., Park Row Bldg., New York City		Jan. 4, 1905
Gaston, Louis Prevost. 143 Liberty St., New York City.		Feb. 1, 1905
Hallsted, James Cottle. 66 Broadway, New York City.		Jan. 4, 1905
Knickerbocker, Curtis Edwin. Engr., M. of W., N. Y., O. & W. Ry. Co., Middletown, N. Y.		Feb. 1, 1905
Knighton, John Albert. Asst. Engr., Bridge Dept., 519 West 124th St., New York City		Jan. 4, 1905
Newman, Emil. 1048 West 8th St., Los Angeles, Cal.		Jan. 4, 1905
Smead, Raphael Chart. 2728 Pennsylvania Ave., N. W., Washington, D. C.		Feb. 1, 1905
Snow, Franklin Augustus. 523 Washington St., Brookline, Mass		Jan. 4, 1905
Triest, Wolfgang Gustav. V. P., The Snare & Triest Co., 39 Cortlandt St., New York City	Jun. Assoc. M.	Sept. 3, 1890 Mar. 6, 1900 Jan. 31, 1905

		Date of Membership.
Wright, Joseph Bodine. Cons. Engr., Steel and Concrete-Steel, 2528 Broadway, New York City	Assoc. M. M.	June 2, 1897 Jan. 31, 1905

ASSOCIATE MEMBERS.

		Date of Membership.
Babcock, William Stuart. 17 Battery Pl., New York City		Feb. 1, 1905
Belknap, Francis Wheelwright. Engr., Phœnix Constr. & Supply Co., 517 East 80th St., New York City		Feb. 1, 1905
Boardman, Howard Edward. Chf. of Party, North Riv. Div., P., N. Y. & L. I. R. R., 558 West 33d St., New York City	Jun. Assoc. M.	Oct. 7, 1902 Jan. 4, 1905
Cole, Harry Outen. 547 Carlton Ave., Brooklyn, N. Y.		Jan. 4, 1905
Conrow, Herman. Contr. Engr., Moorestown, N. J.	Jun. Assoc. M.	May 3, 1898 Jan. 4, 1905
Doty, John Williams. Care, Foundation & Constr. Co., 35 Nassau St., New York City	Jun. Assoc. M.	Nov. 3, 1903 Jan. 4, 1905
Fenton, Louis Gillespie. 22 William St., New York City		Feb. 1, 1905
Graves, Willard Franklin. Asst. Engr., So. Side Elev. Ry., 450 Thirty-seventh Pl., Chicago, Ill.	Jun. Assoc. M.	Oct. 31, 1899 Jan. 4, 1905
Holliday, Alexander Rieman. Engr., M. of W., I. & V. Div., Penn. Co., Union Station, Indianapolis, Ind.	Jun. Assoc. M.	Oct. 7, 1902 Feb. 1, 1905
Jackson, Granbery. Vanberbilt Univ., Nashville, Tenn.		Jan. 4, 1905
Leland, Ora Miner. 127 Cascadilla Pl., Ithaca, N. Y.		Feb. 1, 1905
Machen, Henry Bennett. Asst. Engr., Rapid Transit R. R. Comm. (Res., 315 West 95th St.), New York City	Jun. Assoc. M.	May 2, 1899 Feb. 1, 1905
McConnell, Ira Welch. Montrose, Colo.		Dec, 7, 1904
McPherson, Robert Henry. Room 2515, Park Row Bldg., New York City		Jan. 4, 1905
Oakes, Luther Stevens. Asst. Engr., N. P. Ry., Pier 2, Seattle, Wash.		Jan. 4, 1905
Patch, Walter Woodbury. Asst. Engr., Aqueduct Comm., Jerome Park Reservoir, Kingsbridge, New York City		Sept. 7, 1904
Shire, Moses Edmund. Engr. in Chg., Chicago Union Transfer Ry. Co., 1618 Tribune Bldg., Chicago, Ill.	Jun. Assoc. M.	April 2, 1901 Jan. 4, 1905
Stearns, Fred Lincoln. Dist. Supt. of Street Cleaning, 52 West 126th St., New York City	Assoc. Assoc. M.	June 3, 1902 Jan. 31, 1905
Vail, John Jervis. 102 Fulton St., Rahway, N. J.		Jan. 4, 1905
Whitford, Noble Earl. 11 South Lexington Ave., Albany, N. Y.		Feb. 1, 1905

JUNIORS.

	Date of Membership.
Barrett, Robert Edward. Framingham, Mass	Jan. 31, 1905
Black, Roger Derby. 2d Lieut., Corps of Engrs., U. S. A., War Dept., Washington, D. C	Jan. 3, 1905
Constance, Edward Cartwright. 428 Custom House, St. Louis, Mo	Dec. 6, 1904
Gilman, Charles. 430 West 118th St., New York City	Dec. 6, 1904
Hogan, John Philip. 430 West 118th St., New York City.	Dec. 6, 1904
Hunting, Eugene Nathan. Concrete Steel Engr., 609 House Bldg., Pittsburg, Pa	Nov. 1, 1904
Lindsley, Thayer. 157 West 47th St., New York City	Jan. 3, 1905
Slocum, Curlys Lyon. Room 301, R. R. Bldg., New Haven, Conn	Jan. 3, 1905
Spalding, Walter James. Eng. Aid, Reclamation Service, U. S. Geological Survey, P. O. Box S, Salt Lake City, Utah	Nov, 1, 1904
Stephenson, Stuart Augustus, Jr. Eng. Dept., P. R. R. Co., Office of Asst. Engr. of Constr., Newark, N. J.	Jan. 3, 1905
Van Suetendael, Achille Octave. Yonkers, N. Y	Jan. 3, 1905
Waite, Donald Cramer. 17 Greenvale Ave., Yonkers, N. Y	Jan. 3, 1905
Whitbeck, Lee Field. Care, Rankin Johnson, Durango, Dgo., Mexico	Dec. 6, 1904

RESIGNATIONS.

ASSOCIATE MEMBERS.

	Date of Resignation.
Grandy, Albion Lorenzo	December 31st, 1904

ASSOCIATES.

Stouder, John Burton	December 31st, 1904

JUNIORS.

Anthony, Walter Loring	December 31st, 1904
Tilt, Garret Edward	December 31st, 1904

DEATHS.

Frank, George William..........Elected Member, February 1st, 1899; died January 19th, 1905.

Gould, Edward Sherman.........Elected Member, November 4th, 1885; died January 24th, 1905.

Lindenberger, Cassius Howard..Elected Associate, February 2d, 1892; died January 5th, 1905.

Pope, Macy Stanton..............Elected Associate Member, May 2d, 1900; died December 10th, 1904.

MONTHLY LIST OF RECENT ENGINEERING ARTICLES OF INTEREST.

(January 9th, 1905, to February 3d, 1905.)

NOTE.—*This list is published for the purpose of placing before the members of the Society the titles of current engineering articles, which can be referred to in any available engineering library, or can be procured by addressing the publication directly, the address and price being given wherever possible.*

LIST OF PUBLICATIONS.

In the subjoined list of articles references are given by the number prefixed to each journal in this list.

(1) *Journal*, Assoc. Eng. Soc., 257 South Fourth St., Philadelphia, Pa., 30c.
(2) *Proceedings*, Engrs. Club of Phila., 1122 Girard St., Philadelphia, Pa.
(3) *Journal*, Franklin Inst., Philadelphia, Pa., 50c.
(4) *Journal*, Western Soc. of Engrs., Monadnock Block, Chicago, Ill.
(5) *Transactions*, Can. Soc. C. E., Montreal, Que., Canada.
(6) *School of Mines Quarterly*, Columbia Univ., New York City, 50c.
(7) *Technology Quarterly*, Mass. Inst. Tech., Boston, Mass., 75c.
(8) *Stevens Institute Indicator*, Stevens Inst., Hoboken, N. J., 50c.
(9) *Engineering Magazine*, New York City, 25c.
(10) *Cassier's Magazine*, New York City, 25c.
(11) *Engineering* (London), W. H. Wiley, New York City, 25c.
(12) *The Engineer* (London), International News Co., New York City, 35c.
(13) *Engineering News*, New York City, 15c.
(14) *The Engineering Record*, New York City, 12c.
(15) *Railroad Gazette*, New York City, 10c.
(16) *Engineering and Mining Journal*, New York City, 15c.
(17) *Street Railway Journal*, New York City, 35c.
(18) *Railway and Engineering Review*, Chicago, Ill., 10c.
(19) *Scientific American Supplement*, New York City, 10c.
(20) *Iron Age*, New York City, 10c.
(21) *Railway Engineer*, London, England, 25c.
(22) *Iron and Coal Trades Review*, London, England, 25c.
(23) *Bulletin*, American Iron and Steel Assoc., Philadelphia, Pa.
(24) *American Gas Light Journal*, New York City, 10c.
(25) *American Engineer*, New York City, 20c.
(26) *Electrical Review*, London, England.
(27) *Electrical World and Engineer*, New York City, 10c.
(28) *Journal*, New England Water-Works Assoc., Boston, $1.
(29) *Journal*, Society of Arts, London, England, 15c.
(30) *Annales des Travaux Publics de Belgique*, Brussels, Belgium.
(31) *Annales de l'Assoc. des Ing. Sortis des Ecole Speciales de Gand*, Brussels, Belgium.
(32) *Memoires et Compte Rendu des Travaux*, Soc. Ing. Civ. de France, Paris, France.
(33) *Le Genie Civil*, Paris, France.
(34) *Portefeuille Economique des Machines*, Paris, France.
(35) *Nouvelles Annales de la Construction*, Paris, France.
(36) *La Revue Technique*, Paris, France.
(37) *Review de Mecanique*, Paris, France.
(38) *Revue Generale des Chemins de Fer et des Tramways*, Paris, France.
(39) *Railway Master Mechanic*, Chicago, Ill., 10c.
(40) *Railway Age*, Chicago, Ill., 10c.
(41) *Modern Machinery*, Chicago, Ill., 10c.
(42) *Transactions*, Am. Inst. Elect. Engrs., New York City, 50c.
(43) *Annales des Ponts et Chaussées*, Paris, France.
(44) *Journal*, Military Service Institution, Governor's Island, New York Harbor, 50c.
(45) *Mines and Minerals*, Scranton, Pa., 20c.
(46) *Scientific American*, New York City, 8c.
(47) *Mechanical Engineer*, Manchester, England.
(48) *Zeitschrift*, Verein Deutscher Ingenieure, Berlin, Germany.
(49) *Zeitschrift für Bauwesen*, Berlin, Germany.
(50) *Stahl und Eisen*, Düsseldorf, Germany.
(51) *Deutsche Bauzeitung*, Berlin, Germany.
(52) *Rigasche Industrie-Zeitung*, Riga, Russia.
(53) *Zeitschrift*, Oesterreichischer Ingenieur und Architekten Verein, Vienna, Austria.
(54) *Transactions*, Am. Soc. C. E., New York City, $5.

(55) *Transactions*, Am. Soc. M. E., New York City, $10.
(56) *Transactions*, Am. Inst. Min. Engrs., New York City, $5.
(57) *Colliery Guardian*, London, England.
(58) *Proceedings*, Eng. Soc. W. Pa., 410 Penn Ave., Pittsburg, Pa., 50c.
(59) *Transactions*, Mining Inst. of Scotland, London and Newcastle-upon-Tyne, England.
(60) *Municipal Engineering*, Indianapolis, Ind., 25c.
(61) *Proceedings*, Western Railway Club, 225 Dearborn St., Chicago, Ill., 25c.
(62) *American Manufacturer and Iron World*, 59 Ninth St., Pittsburg. Pa.
(63) *Minutes of Proceedings*, Inst. C. E., London, England.
(64) *Power*, New York City, 20c.
(65) *Official Proceedings*, New York Railroad Club, Brooklyn, N. Y., 15c.
(66) *Journal of Gas Lighting*, London, England, 15c.
(67) *Cement and Engineering News*, Chicago, Ill., 25c.
(68) *Mining Journal*, London, England.
(69) *Mill Owners*, New York City, 10c.
(70) *Engineering Review*, New York City, 10c.
(71) *Journal*, Iron and Steel Inst., London, England.
(72) *Street Railway Review*, Chicago, 30c.
(73) *Electrician*, London. England, 18c.
(74) *Transactions*, Inst. of Min. and Metal., London, England.
(75) *Proceedings*, Inst. of Mech. Engrs., London, England.
(76) *Brick*, Chicago, 10c.
(77) *Journal*, Inst. Elec. Engrs., London, England.
(78) *Beton und Eisen*, Vienna, Austria.
(79) *Forscherarbeiten*, Vienna, Austria.
(80) *Tonindustrie-Zeitung*, Berlin, Germany.
(81) *Zeitschrift fur Architektur und Ingenieurwesen*, Wiesbaden, Germany.
(82) *Dinglers Polytechnisches Journal*, Berlin, Germany.

LIST OF ARTICLES.

Bridge.

General Methods for the Calculation of Statically Indeterminate Bridges, as Used in the Check Calculations of Designs for the Manhattan Bridge and the Blackwell's Island Bridge, New York.* Frank H. Cilley. (54) Vol. 58.
The Nantes Transfer-Bridge.* (11) Jan. 13.
The Boston Bridge Works.* (14) Jan. 14.
The Substructure of the Cambridge Bridge, Boston.* (14) Jan. 14.
A 100-Foot Plate-Girder Span with Unusual Bearings.* (14) Jan. 14.
Trunnion Bascule Bridge at Northwestern Ave., Chicago.* (13) Jan. 19.
The Bethlehem Junction Bridge.* (14) Jan. 21.
The Reconstruction of the Point Bridge, Pittsburg, Pa.* Willis Whited. (13) Jan. 26.
The Ashtabula Concrete Bridge of the Lake Shore.* (15) Jan. 27.
Rebuilding the Big Four Bridge at Terre Haute.* (15) Jan. 27.
The Suspension Bridge Failure at Charleston, West Virginia.* Addison M. Scott, M. Am. Soc. C. E. (13) Feb. 2.
Comparisons of Full-Sized and Specimen Tests of Very Large Steel Eye-Bars. (13) Feb. 2.
Le Pont Troitsky, à Saint-Pétersbourg, Commande Électrique de la Partie Tournante.* (33) Jan. 21.
Die Fahrbahn der neuen Mont Blanc Brücke in Genf.* (78) Pt. 1, 1905.
Berechnung der Scheitelstärke Steinerner Dreigelenkbrücken.* Wilh. Schnidtmann. (51) Dec. 30.
Balkenbrücke in Eisenbeton in Bamberg.* Luft. (51) Jan. 2.
Zur Statischen Untersuchung von Flachen Gewölben.* Josef Schreier. (53) Jan. 6.
Streben-Auswechslung mit einem Zugstangen-Systeme an einer Eisenbahn-Gitterbrücke.* Julius Novák. (53) Jan. 13.

Electrical.

Some Interesting Phases of Long-Distance Telephony.* S. G. McMeen. (4) Dec.
Press Button Electric Lift.* (12) Dec. 30.
The Automatic v. the Manual Telephone Exchange. Kempster B. Miller. (Abstract of Paper read before the International Elec. Cong.) (26) Dec. 30.
The Uncertainty of Fuses. (26) Dec. 30.
A Method of Designing Induction Motors.* H. M. Hobart. (Abstract of Paper read before the International Elec. Cong.) (26) Dec. 30.
High-Frequency Telephone Circuit Tests. A. E. Kennelly. (Abstract of Paper read before the International Elec. Cong.) (26) Dec. 30.
A Multiple-Dial Potentiometer.* Albert Campbell. (26) Dec. 30.

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* Illustrated.

Electrical—(Continued).

Messrs. Schneider and Co.'s New Electricity Works.* (11) Dec. 30.
Automatic Telephony.* (11) Jan. 6.
Standard Form of Tender for Cables. (73) Jan. 6.
Recent Developments in Self-Excited Compounded Alternators.* Alexander Heyland. (Abstract of Paper read before the International Elec. Cong.) (73) Jan. 6.
A Direct Measurement of the Thomson Thermoelectric Coefficient in Soft Iron. Edwin H. Hall. (Abstract of Paper read before the Amer. Assoc. for the Advancement of Science.) (27) Jan. 7.
The Transmission of Electrical Energy Without Wires as a Means for Furthering Peace. Nikola Tesla. (27) Jan. 7.
The Electrical Testing Laboratories.* Clayton H. Sharp. (27) Serial beginning Jan. 7.
4 000-kw. Generators for the California Gas & Electric Corporation.* (27) Jan. 7.
On Direct-Current Balancers.* A. E. Kennelly and S. E. Whiting. (27) Jan. 7.
The Tuning of Thermoelectric Receivers for Electric Waves.* A. D. Cole. (27) Jan. 7.
The Ratio between Electrical and Gravitational Forces. Bergen Davis. (Paper read before the Amer. Assoc. for the Advancement of Science.) (27) Jan. 7.
Inter-Pole Variable Speed Motor.* (27) Jan. 7; (40) Jan. 27; (17) Jan. 28.
Special I. T. E. Circuit-Breaker.* (27) Jan. 7.
160 000-Volt Testing Transformer.* J. J. Frank. (27) Jan. 7.
Roller Direct-Reading Bend Tester.* (27) Jan. 7.
Canadian Niagara Power To-Day.* (27) Jan. 7.
Direct Wheatstone Working Between England & Teheran.* T. W. Stratford-Andrews. (73) Jan. 13.
Discriminating Relays and Cut-Outs.* M. B. Field. (26) Jan. 13.
The Diesel Engine in Electricity Generating Stations. A. J. Lawson. (73) Jan. 13.
Mercury Tubes in a Newspaper Pressroom.* (27) Jan. 14.
Commutation at Starting of Alternating-Current Motors with Commutator. Marius Latour. (27) Jan. 14.
Triumph Variable-Speed Motor.* (27) Jan. 14.
Wireless Telegraphy and War Correspondence.* Lionel James. (29) Jan. 20.
The Electrical Equipment of a London Hospital.* (26) Jan. 20.
The Sullivan Outgoing Signal Recorder.* (26) Jan. 20; (73) Jan. 20.
The Fisher-Street Sub-Station of the Metropolitan Electric Supply Co.* (73) Jan. 20.
A New American System of Wireless Telegraphy.* A. Frederick Collins. (27) Jan. 21.
The Electrical Equipment of the Bellevue-Stratford Hotel, Philadelphia.* (27) Jan. 21.
The Orling-Armstrong Electro-Capillary Recorder.* (19) Jan. 21.
Electrical Power from the Welland Canal.* (27) Jan. 21.
Hydro-Electric Power Plants in the Canadian Niagara District.* Cecil B. Smith. (9) Feb.
Electric-Power Supply from Central Stations in Great Britain.* G. L. Addenbrooke. (9) Feb.
District Electric Power Distribution.* (27) Jan. 28.
A Working Diagram of the Alternating-Current Synchronous Motor.* A. E. Kennelly. (27) Jan. 28.
The Tantalum Incandescent Lamp.* (27) Jan. 28.
Central Station Distribution. C. H. Williams. (Abstract of Paper read before the Northwestern Elec. Assoc.) (27) Jan. 28.
Novel Construction of Direct-Current Motors.* (27) Jan. 28.
Series Alternating Arc Lamps. E. P. Warner. (Abstract of Paper read before the Northwestern Elec. Assoc.) (27) Jan. 28.
Crossing Railroads by Power Transmission Lines. P. M. Lincoln. (Abstract from *Journal* of the Electric Club of Pittsburg.) (14) Jan. 28.
Tests of Auxiliaries at the Cambridge Electric Light Station. Lionel S. Marks. (Abstract from the *Harvard Engineering Journal.*) (14) Jan. 28.
A Model Electric Mining Plant: The First High-Tension Transmission Plant Built in America by a Mining Company for Its Own Use.* H. A. Pharo. (10) Feb.
The Widening Use of Small Electric Motors, with Special Reference to American Practice.* F. H. Kimball. (10) Serial beginning Feb.
Breaks in Overland Telegraphic Communication Due to Storms: Some Proposed Remedies. William Maver, Jr. (10) Feb.
Special Forms of Cranes.* Joseph Horner. (10) Serial beginning Feb.
De Forest-Ives Electric Wave-Length Standard.* A. Frederick Collins. (19) Feb. 4.
The Installation of a Transmission Plant. (From *The Electric Club Journal.*) (19) Feb. 4.
Opening of the Niagara Canadian Power Company's Plant.* (46) Feb. 4.

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* Illustrated.

Electrical—(Continued).

Règles pour les Offres, la Fourniture et les Essais de Machines Électriques Proposées par les Associations Françaises de Propriétaires d'Appareils à Vapeur Ayant un Service Electrique. (36) Dec. 25.

L'Installation Électrique de la Tissanderie Conradi et Friedmann.* Emile Guarini. (36) Dec. 25.

Le Transmetteur Kotyra.* R. Wittebolle. (36) Dec. 25.

Bouchons pour Piles et Accumulateurs Electriques.* (34) Jan.

Le Pont Troïtsky, à Saint-Pétersbourg, Commande Électrique de la Partie Tournante.* (33) Jan. 21.

Abstimmung in der Drahtlosen Telegraphie. Gustav Eichorn. (82) Jan. 7.

Die Elektrizitätswerke der Stadt München.* K. Meyer. (48) Serial beginning Jan. 14.

Das Verhalten und die Pflege des Kommutators im Betriebe.* Karl Klein. (82) Jan. 14.

Die Dampfmaschinenanlage des Drehstromwerkes der Stadt Hannover.* Gustav ter Meer. (48) Jan. 21.

Explosionsmotoren mit Einführung Verdampfender Flüssigkeiten. K. Schreber. (Paper read before the Naturforscherversammlung in Breslau.) (82) Serial beginning Jan. 21.

Marine.

Trials of the Troopship *Dufferin*. (11) Dec. 30.

Engines of H. M. S. *Black Prince*.* (12) Dec. 30.

Modern Machinery and Electrical Equipment at Yarrow Yards in England.* Frank C. Perkins. (41) Jan.

Machinery of the Italian Battleship *Regina Margherita*.* (12) Jan. 6.

The Machinery of H. M. S. *Argyll*.* (11) Jan. 13.

The Clyde and Naval Work. (12) Jan. 13.

The Salvage of Ships.* (11) Serial beginning Jan. 20.

Some Vessels of the Russian Baltic Fleet.* (12) Jan. 20.

Progress of Warships and Machinery Building in England. (12) Jan. 20.

A Twelve-Cylinder 150 B. H. P. Racing Marine Gasoline Motor.* (19) Jan. 28.

The Turret and Barbette of a Battleship.* (46) Feb. 4.

Notice sur les Procédés à l'Air Comprimé Employés pour la Construction d'un Nouveau Bassin à Radoub dans l'Arsenal Maritime de la Carraca (près Cadix). M. Zschokke. (43) 3e Trimestre, 1904.

Mechanical.

Forging Machinery. Jas. H. Baker. (58) Dec.

The Garrett Re-Heating Furnace.* J. S. Trinham. (Paper read before the Staffordshire Iron and Steel Inst.) (22) Dec. 30.

Combination Turret Lathe.* (11) Dec. 30.

The Suction Gas Producer.* (26) Dec. 30.

Wheel Cutting Machines. Thomas R. Shaw. (47) Serial beginning Dec. 31.

Combined Coking and Sprinkling Stoker.* (47) Dec. 31.

Hamilton's Four-Stroke Cycle Gas Engine.* (47) Dec. 31.

Chelmsford Motor Omnibuses: Great Western Railway.* (21) Jan.

Petrolite Lamps.* (21) Jan.

An Automobile Freight Truck.* (41) Jan.

Something About Corliss Valves.* W. H. Wakeman. (From *Graphite*.) (41) Jan.

A Model Sand-Brick Plant. H. O. Duerr. (Abstract of Paper read before the National Assoc. of Mfrs. of Sand-Lime Products.) (76) Jan.

Drying of Sand. P. L. Simpson. (Abstract of Paper read before the National Assoc. of Mfrs. of Sand-Lime Products.) (76) Jan.

Methods of Manufacture.* S. V. Peppel. (Abstract of Paper read before the National Assoc. of Mfrs. of Sand-Lime Products.)* (76) Jan.

An Electrical Car Installation for the Chicago Brick Co.* (76) Jan.

Generation of Steam by Waste Heat from Water-Gas Plant.* (Two Papers read before the Amer. Gaslight Assoc.) (66) Jan. 3.

Distillation of Coal by Means of Highly-Heated Gas. (66) Jan. 3.

The Flow of Gas Through Passages in Gas Apparatus, Openings in Plates, Valves, etc. F. Southwell-Cripps, Assoc. M. Inst. C. E. (66) Jan. 3.

Conway Corporation Gas-Works.* (66) Jan. 3.

The Design of Drop Valves.* (12) Jan. 6.

New Electrical Ignition for Petrol Motor-Cars.* (26) Jan. 6.

Practical Data on European Practice with Steam Turbines.* Franz Koester. (14) Jan. 7.

An Improved Engine-Lathe with Quick-Change Feed Device.* (17) Jan. 7.

A New Design of Engine Lathe.* (17) Jan. 7.

Reversible Internal-Combustion Engine.* (47) Jan. 7.

Fan and Blower Tests.* H. E. Field. (Paper presented before the Pittsburg Foundrymen's Assoc.) (47) Jan. 7.

Notes on Power Production.* William McClellan. (24) Jan. 9.

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* Illustrated.

Mechanical—(Continued).

The Naphthaline Question at the Bradford Meeting of the Yorkshire Junior Gas Association.* (From _Journal of Gas Lighting._) (24) Jan. 9.
Gas Works and Gas Supply of Lausanne. (66) Jan. 10.
Direct Casting from the Blast Furnace: The Methods of Production of Cast Iron Tunnel Segments as Pursued at the Works of Thomas Butlin & Co., Limited, Wellingborough, Northamptonshire, England. (20) Jan. 12.
The Norwalk Air Compressor.* (20) Jan. 12.
Coil Clutch Reversing Gear for Rolling Mills.* (62) Jan. 12.
Calorimetry. John F. Simmance. (11) Jan. 13.
Petroleum and Petrol Engines.* (12) Jan. 13.
Standardising Electric Motors for Machine Tools. (Two Papers read before the American Machine Tool Builders' Assoc.) (12) Jan. 13.
The Compound Steam-Turbine.* (11) Serial beginning Jan. 13.
Cylindrical Water-Tube Boiler.* (12) Jan. 13.
The Electra Steam Turbine.* Walter Rappaport. (26) Jan. 13.
Pattern Making. R. Watson. (Paper read before the Rugby Engineering Soc.) (47) Serial beginning Jan. 14.
Pressure Raising Plant at the Dover (England) Gas Works.* (From _Journal of Gas Lighting._) (24) Jan. 16.
Carbonizing in Bulk. (From the _Gas World._) (24) Jan. 16.
The "Helios" Die-Stock.* (66) Jan. 17.
The Trend of Gas Invention. (66) Jan. 17.
The Theory of the Incandescent Mantle. Vivian B. Lewes. (Lecture before the Junior Inst. of Engrs.) (66) Jan. 17.
Coke Handling Plant at the Rossendale Union Gas-Works.* (66) Jan. 17.
Efficiency Test of a Direct-Connected Steam Turbine Fan Blower Set.* C. R. Waller. (13) Jan. 19.
The Ess Ess Revolving Chuck.* (20) Jan. 19.
Oil as Fuel for Core Ovens.* S. F. Barnes. (Paper read before the Philadelphia Foundrymen's Assoc.) (20) Jan. 19.
The Calorific Values of Solid and Gaseous Fuels. (11) Jan. 20.
A New Type of Explosion Engine.* (12) Jan. 20.
The Kryszat Air-Compressor.* (11) Jan. 20.
A Comparison of Different Types of Steam Turbine.* R. M. Neilson. (Paper read before the Manchester Assoc. of Engrs.) (47) Serial beginning Jan. 21; Abstract (12) Jan. 20.
Producer Gas from Common Bituminous Slack.* (22) Jan. 20.
Improved Compensated Speed Indicator.* (73) Jan. 20.
The Latest German Form of Vertical Retort Setting: Making Gas "Entirely Free from Naphthalene." (24) Jan. 23.
Notes on the Thermal Efficiency of Modern Motive-Power Engines. B. H. Thwaite. (From _Vulcan._) (66) Jan. 24.
The Setting or Hydration of Portland Cement. Clifford Richardson. (Paper read before the Assoc. of Amer. Portland Cement Mfrs.) (13) Jan. 26.
The Prentice Vertical Drill.* (20) Jan. 26.
The International Portland Cement Works at Hull, P. Q., Canada.* John McClelland Bulkley. (14) Jan. 28.
Application of Motors to Machine Tools.* J. M. Barr. (18) Jan. 28.
An Interesting Producer-Gas Plant.* Emile Guarini. (19) Jan. 28.
Incandescent Lighting by Means of Acetylene and the Carburization of Acetylene. N. Caro. (Abstract translated from _Revue Generale de Chimie Pure et Appliquée._) (19) Jan. 28.
A New Type of Rotary Pump.* Emile Guarini. (19) Jan. 28.
New Feed-Water Heater.* (9) Feb.
The Economy of Small-Size Coal for the Power Plant. Percival Robert Moses. (9) Feb.
Multi-Speed Motor.* (25) Feb.
Electrically Operated Lathes in Modern European and American Shops.* Frank C. Perkins. (41) Feb.
Strength and Proportion of Members to Resist a Given Moment of Force.* Frank B. Kleinhans. (41) Feb.
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The Revival of De Lesseps' Sea-Level Plan for the Panama Canal. H. L. Abbot. (9) Feb.
The Work of the Commission on the Panama Canal. C. E. Grunsky. (9) Feb.
Le Canal de Dortmund à l'Ems.* La Rivière and Bourguin. (43) 3e Trimestre, 1904.
Projet d'Ascenseur pour Bateaux à Prerau, sur le Canal du Danube à l'Oder.* (33) Jan. 7.
Le Canal des Deux-Mers. Francis Marre. (36) Serial beginning Jan. 10.
Der Internationale Wettbewerb um das Probe-Schiffshebewerk im Zuge des Donau-Oder-Kanales bei Prerau.* F. Eiselen. (51) Serial beginning Jan. 21.

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* Illustrated.

Vol. XXXI. FEBRUARY, 1905. No. 2.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PAPERS AND DISCUSSIONS.

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THE COMPENSATING WORKS OF THE LAKE SUPERIOR POWER COMPANY.

By G. F. Stickney, Assoc. M. Am. Soc. C. E.
To be Presented March 15th, 1905.

Lake Superior, the most westerly and the largest of the Great Lakes, covering an area of about 32 000 sq. miles, has a mean elevation of 602.5 ft. above sea level. The outlet of the lake is through Lake Huron, by way of the St. Mary's River, with the Province of Ontario on the north, and the State of Michigan on the south. At the head of the river is a rocky barrier, forming the "Soo" Rapids, which have a fall of 19 ft. in a distance of 3 600 ft. At the upper end of the rapids the river is 2 400 ft. wide, and is crossed by a railroad bridge of ten spans. This bridge connects the two cities of Sault Ste. Marie. The outflow through St. Mary's River, according to the best information available, varies from 56 157 to 125 147 cu. ft. per sec., with an average flow of about 92 000 cu. ft. per sec., the volume depending upon the stage of the lake.

The location is unusually favorable for the development of water-

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Note.—These papers are issued before the date set for presentation and discussion. Correspondence is invited from those who cannot be present at the meeting, and may be sent by mail to the Secretary. Discussion, either oral or written, will be published in a subsequent number of *Proceedings*, and, when finally closed, the papers, with discussion in full, will be published in *Transactions*.

power, and advantage of the situation has been taken by the Lake Superior Power Company to establish various industrial plants on the Canadian side, where a water-power canal was already in operation. On the American side there was a small electric light plant, utilizing water-power. The Lake Superior Power Company was preparing to develop 40 000 h-p. on the American side, and, for this purpose, had under construction a canal and a power-house.

The canal commences above the rapids, and is excavated through the City of Sault Ste. Marie, Mich., returning to the river below the rapids, with a total length of 2 miles. It is 200 ft. wide, 22 ft. deep, and the water will have a velocity of 7 ft. per sec., furnishing 32 000 cu. ft. per sec. at the wheel pits, with an effective head of 16 ft. Thus, the quantity of water to be withdrawn from the lake is about 35% of the mean average flow over the rapids. The elevation of the surface of Lake Superior varies within a limit of 2.4 ft., depending upon the rainfall and the season of the year. If an artificial outlet were provided, increasing the natural discharge 35%, it is evident that the lake would be lowered, gradually, until such time that the depth in the channels was reduced to a stage that would just accommodate the flow of surplus water, and the lake would remain at this low level. Such a change, in addition to reducing the power output, would decrease the depth in all the channels and harbors of Lake Superior. To provide against such a contingency, regulating works, at the head of the rapids, were necessary, to restrict and to control the flow of water in the natural channel and to compensate for the volume taken out through the water-power canal. A wing-dam, or some similar structure, closing up part of the natural channel, would effect this compensation, if the channel closed were equal in area of cross-section to the water-power canal, but such a structure, adjusted to the mean flow, would increase the low-water discharge and would decrease the high-water discharge, thus extending the range of fluctuation of the lake level. A more flexible method of compensation was necessary, to avoid antagonizing the vast interests on the lake, which would certainly oppose any change of the natural conditions. It was required, therefore, to design a structure which could be adjusted to present a greater or a smaller obstruction in the channel, according to the stage of the lake, which would compensate at all times.

Under the direction of Alfred Noble, Past-President, Am. Soc. C. E., Consulting Engineer, plans were prepared for regulating works, including four sections, as follows:

1.—An embankment,
2.—A movable dam,
3.—A crib dam,
4.—A submerged weir.

Each section was to be about 242 ft. long, corresponding to the length of the spans of the International Railroad Bridge, and the works were located on a line parallel to, and 150 ft. above, the center line of that structure, opposite the first, second, third and fourth spans, numbering from the Canadian side.

The embankment is a simple fill across a shallow part of the river, 12 ft. wide on top, with side slopes of 1½ to 1, made of earth and stone, with height sufficient to prevent its being overtopped by high water during a storm.

The movable dam, Fig. 1, which is the chief feature of the design, is intended to furnish the flexible element. Several different types were considered, and the form finally adopted was the "Stoney" Sluice Gate. This is a steel gate, placed between masonry piers, lifting vertically out of the water. All the working parts of this dam are above water, making repairs easy, and the gate cannot become jammed by drift or floating ice. Four openings, of 52¼ ft. each, were provided, and the total length of dam, including piers and abutment, is 256 ft. The piers, Fig. 2, are 20 ft. high, with vertical sides. The up-stream end is vertical for 7 ft., and has a batter of 1 on 1 in the next 9 ft., forming an ice breaker; the remainder is vertical. The piers are recessed on each side to form bearings for the gates. From the gate recesses, forward, the piers are almost entirely of cut stone. The nose stones and the down-stream quoins are granite. The remainder of the stone, including the down-stream nose stones and the coping, is oolitic limestone. The body of the piers is concrete, with a facing of granite paving blocks, with headers and stretchers laid alternately.

The foundations are of concrete, and a concrete sill, with top surface of granite paving blocks, 6 in. thick, extends between the piers. This sill is 39 ft. wide. The outer pier is 9 ft. wide and 62 ft. 8¾ in. long. The three intermediate piers are 8 ft. wide and

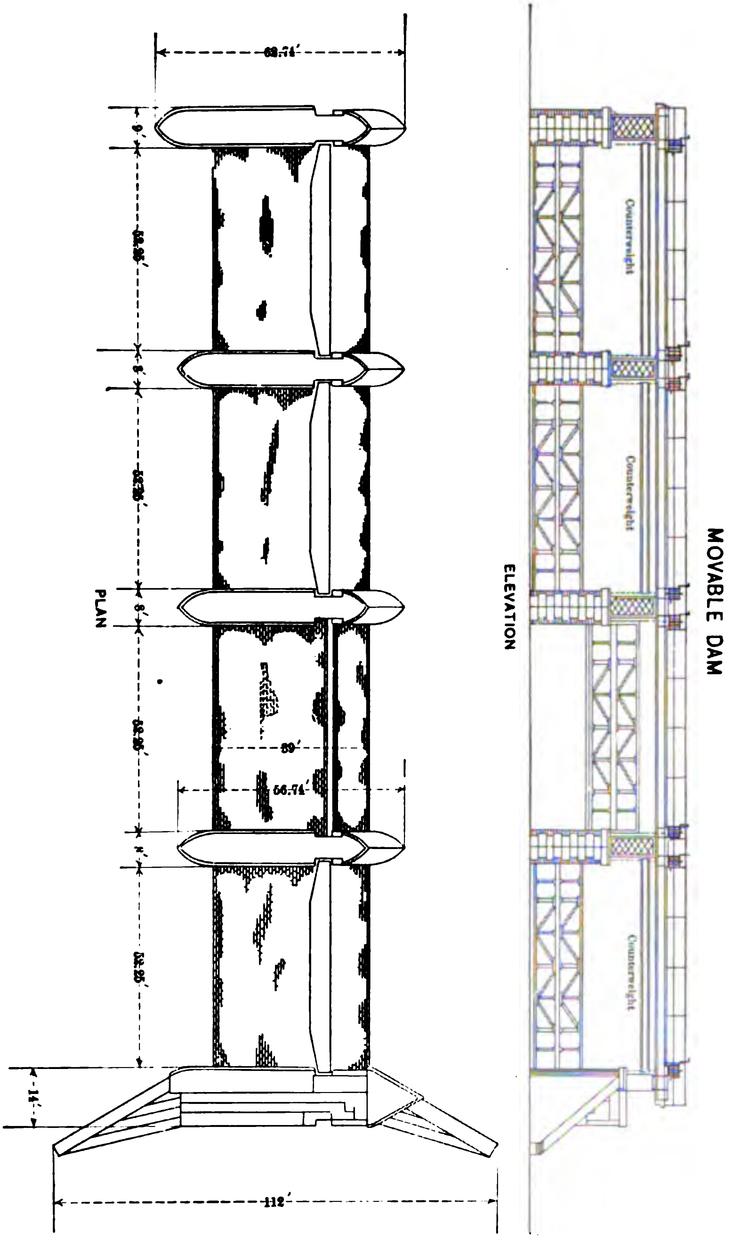

MOVABLE DAM
ELEVATION
PLAN
Counterweight
Counterweight
Counterweight
62.74′
9′
53.25′
8′
53.25′
8′
53.25′
59′
56.74′
8′
53.25′
14′
112′

FIG. 1.

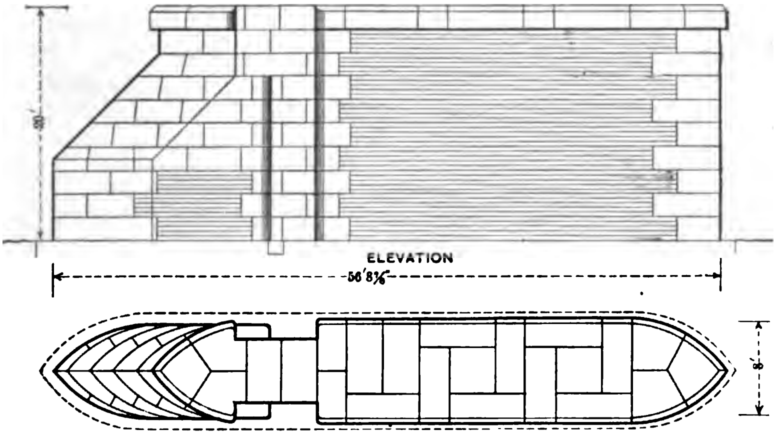
56 ft. 8⅞ in. long. At the in-shore end of the dam there is an abutment with wing-walls. This abutment is 14 ft. wide, reducing by offsets to 6 ft. on top. It is 24 ft. high and 112 ft. long, from end to end of wing-walls. The piers and abutment are covered with coping which projects 6 in. The masonry is of ample dimensions to resist the pressure of water and ice against the closed gates.

The gates, Fig. 3, made entirely of steel, are 54 ft. 3⅛ in. long (from center to center of end rollers), and are 12 ft. 11⅛ in. high. At mean high water they will be immersed 12 ft.

The gates have three horizontal ribs, placed at top, bottom and intermediate. They are 5 ft. wide through the center portion, and are reduced to 3 ft. at the ends. The ribs are connected by end plates, by three sets of intermediate cross-frames, by diagonal bracing on the back, and by a sheathing of ⅜-in. steel plates on the face. The gates bear against cast-steel track-plates, bolted in the quoins of the piers. Trains of live rollers are introduced between the gates and their tracks to reduce the friction when the gates are operated. The weight of each gate is 59 400 lb., which is nearly balanced by a counterweight of 57 600 lb. The gates are operated by hand-power winches, mounted on steel towers at each pier. The towers are connected by a light steel bridge, to give access to the machinery. Sprocket chains, attached to the ends of the gate, pass over sprocket wheels driven by the winch gearing, and connect with the counterweight. This counterweight is a horizontal box-girder, loaded with cast-iron weights, and extends the entire length of the gate. Two winches are provided for each gate (one over each end), and are connected by a horizontal shaft, to insure their working together.

The crib dam, Fig. 4, is 240 ft. long, and consists of fifteen rock-filled cribs, of such height that their tops will be 4½ ft. below mean high water. These cribs are 12 ft. wide and 19 ft. long. They are built of logs, 10 in. in diameter at the small end, and notched and drift-bolted together where they overlap. The projecting ends of the logs in one crib interlock with the projecting ends of those in the adjoining cribs. They form the center of a rock fill which is carried to a height of 5½ ft. above mean high water, or 10 ft. above the top of the cribs. This rock fill is level on top for a width of 12 ft., and slopes away on each side to the bottom of the river. The up-stream slope is 1 on 1, and the down-stream slope is 1 on 2.

INTERMEDIATE PIER

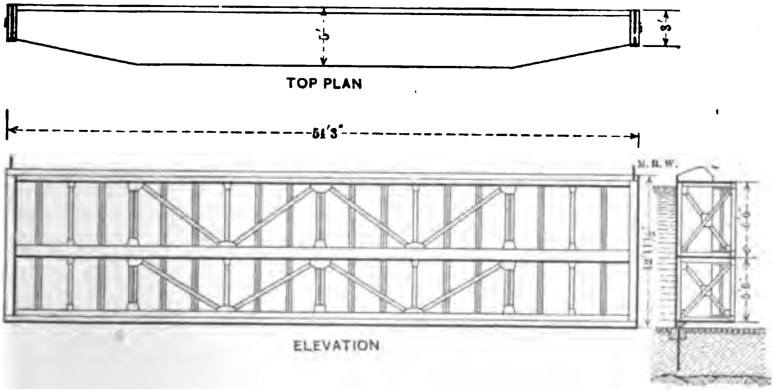


ELEVATION

PLAN

Fig. 2.

STEEL GATE



TOP PLAN

ELEVATION

SECTION

Fig. 3.

The submerged weir, Fig. 5, is 240 ft. long and 20 ft. wide, with its crests 4½ ft. below mean high water. A frame of 12 by 12-in. timber, about 3 ft. high, is anchored to the underlying rock by 8-ft. wedge-bolts, 1¼ in. in diameter, and is filled with concrete. The crest of the weir, 3 ft. higher than the sides, is rounding, with a radius of 4 ft. 9 in., and is paved for a width of 5 ft. with granite paving blocks, bonded into the concrete. The upper slope, 1 on 1, and the lower slope, 1 on 4, are tangent to the curve of the crest.

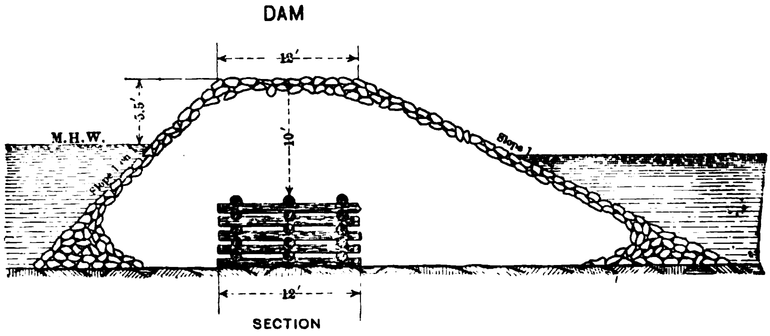


Fig. 4.

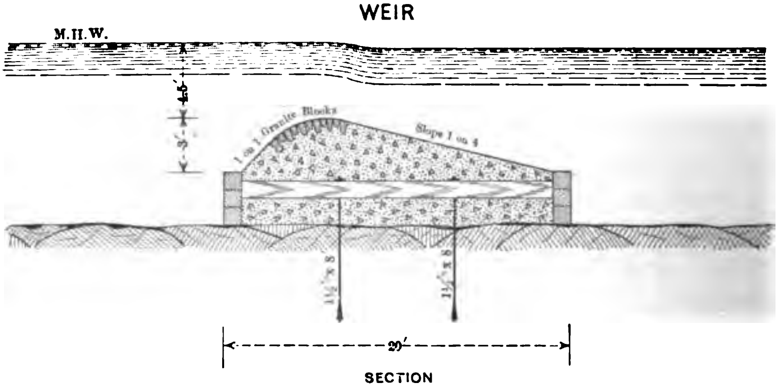


Fig. 5.

H. von Schon, M. Am. Soc. C. E., Chief Engineer of the Michigan Lake Superior Power Company, was in general charge of the water-power development, on the American side, together with the work in the rapids, and the writer was employed as Assistant Engineer, in charge of constructing the compensating works.

PLATE XVI.
PAPERS, AM. SOC. C. E.
FEBRUARY, 1905.
STICKNEY ON
LAKE SUPERIOR COMPENSATING WORKS.

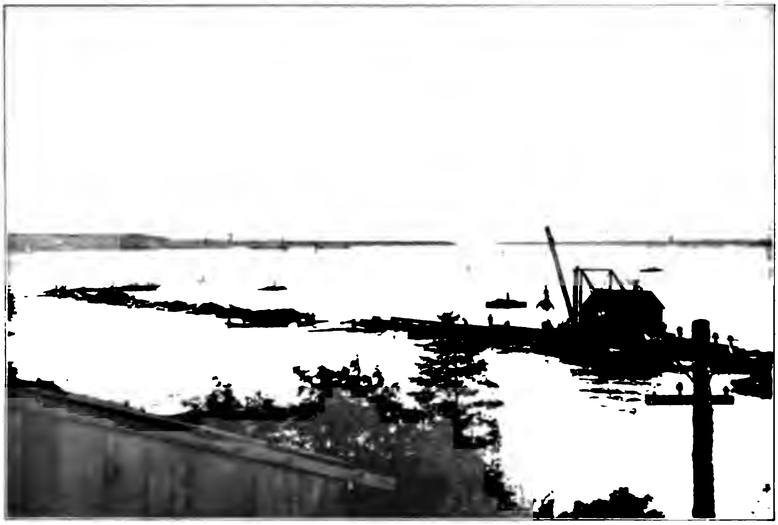


FIG. 1.—LAKE SUPERIOR COMPENSATING WORKS. THE BREAKWATER, FROM THE RAILROAD, AUG. 16TH, 1901.

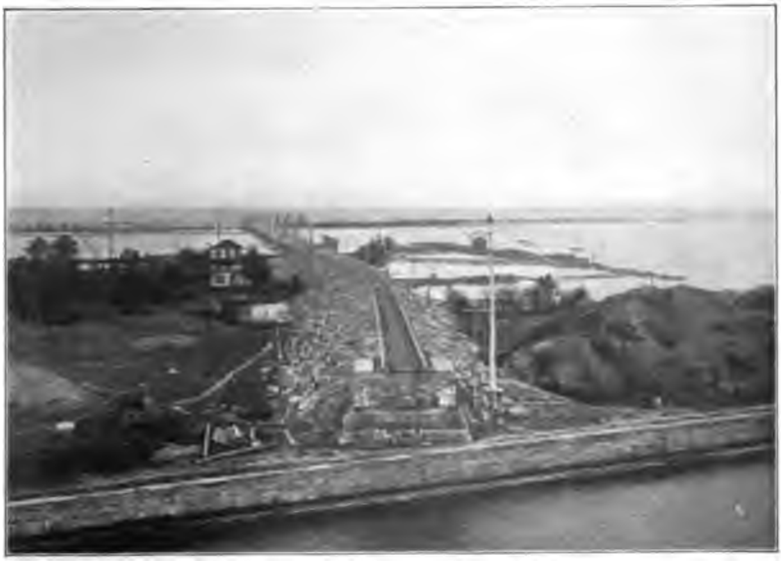


FIG. 2.—LAKE SUPERIOR COMPENSATING WORKS. VIEW FROM CANADIAN CANAL, SEPT. 24TH, 1901

The sections were to be built one at a time, as it was not desirable to obstruct a large portion of the channel prior to the opening of the water-power canal. The movable dam was to be constructed first and then the submerged weir, the crib dam, and the embankment, in order. This programme was not entirely carried out, however, as delays in the construction of the water-power canal made it desirable to suspend operations in the rapids, after the completion of the movable dam; and, though the embankment was built, the remaining sections were left to a future time, when the quantity of water withdrawn through the canal would make the completion of the regulating works necessary.

Construction was commenced on June 13th, 1901. A cement storehouse, blacksmith shop and other buildings were erected, and the plant was assembled, on Gorby's Island, at the north end of the International Bridge. Through arrangement with the Algoma Central and Hudson Bay Railroad Company (one of the subsidiary organizations of the Lake Superior Power Company), a short spur track was built from the Canadian Pacific Railway, to give access for materials, etc. This track leaves the main line at a high embankment, and, with nearly 180° of 24° curve, drops on a 4% grade down to the level ground at the site of the work. The following plant was used:

Two 60-ft. derricks, with double-drum hoisting engines;
One steel traveling derrick;
One No. 6 gyratory stone crusher, with engine and boiler;
One 4-ft. cube, concrete mixer and engine;
One 1-yd. orange-peel bucket;
Eight 1½-yd. side-dump cars;
Six small platform cars;
Track, 2 000 lin. ft., 30-in. gauge, 25-lb. rail;
Four small barges;
One large sand barge, with 12-in. sand pump, and engine;
One small steam launch;
Two 12-in. centrifugal pumps, with engines and boilers;
One 4-in. pulsometer;
Two steam drills;
Three 20-h-p. boilers;
Skiffs, blacksmith's outfit, small tools, etc.

Tugboats and a dredgeboat were hired, as needed.

The plans contemplated the construction of the dam inside of a single, large coffer-dam. This necessitated the erection of a breakwater to protect the site, as the river had a velocity of 10 ft. per sec. and was about 12 ft. deep. The construction of a large coffer-dam, in such a current, was not considered practicable, and later experience entirely justified this conclusion. The length of breakwater required to protect the site was 980 ft. At the shore end the water was quite shallow, not more than 2 ft. deep, and it gradually increased to 15 ft., at the outer end. The breakwater was made of stone-filled cribs spaced 16 ft. apart, in the clear. The intervals were left to provide passages for the water, to avoid damming up the river and thereby increasing the current while the cribs were being placed. These openings were afterward filled.

The cribs in shallow water were 16 ft. square, while those in deep water were 16 by 24 ft., and placed with the longest side parallel to the current. They were of spruce logs, from 8 to 10 in. in diameter, fastened at the corners with ¾-in. drift-bolts, and had a bottom of logs on which the stone filling rested. The breakwater was started on July 6th, but was not completed until September, slow progress being made on account of the difficulty in securing sufficient labor. Only lumbermen who were accustomed to logging in swift water could be employed, as this work, on account of its location in the head of the rapids, was particularly hazardous.

The cribs in the shallow water near shore were built in place without much difficulty, but, as the depth and the current increased, a different method had to be adopted. A convenient site was found, about half a mile above the breakwater, where there was little current and ample depth, to build the cribs in the water, from which place, with the aid of a tugboat, they were floated down to the work, one at a time. The river for 2 000 ft. above the breakwater was obstructed by numerous shoal spots, formed of loose rock and boulders brought down by the ice, and though these places were marked by buoys, they were too close to the rapids to risk sending the tug into this region, therefore the cribs were floated down on the end of a line 2 000 ft. long.

Stone for filling the cribs was received on cars at the railroad dock, a mile or more above, where it was loaded on small barges. The tug took a barge in tow, and, with a crib hitched on the front

BREAKWATER

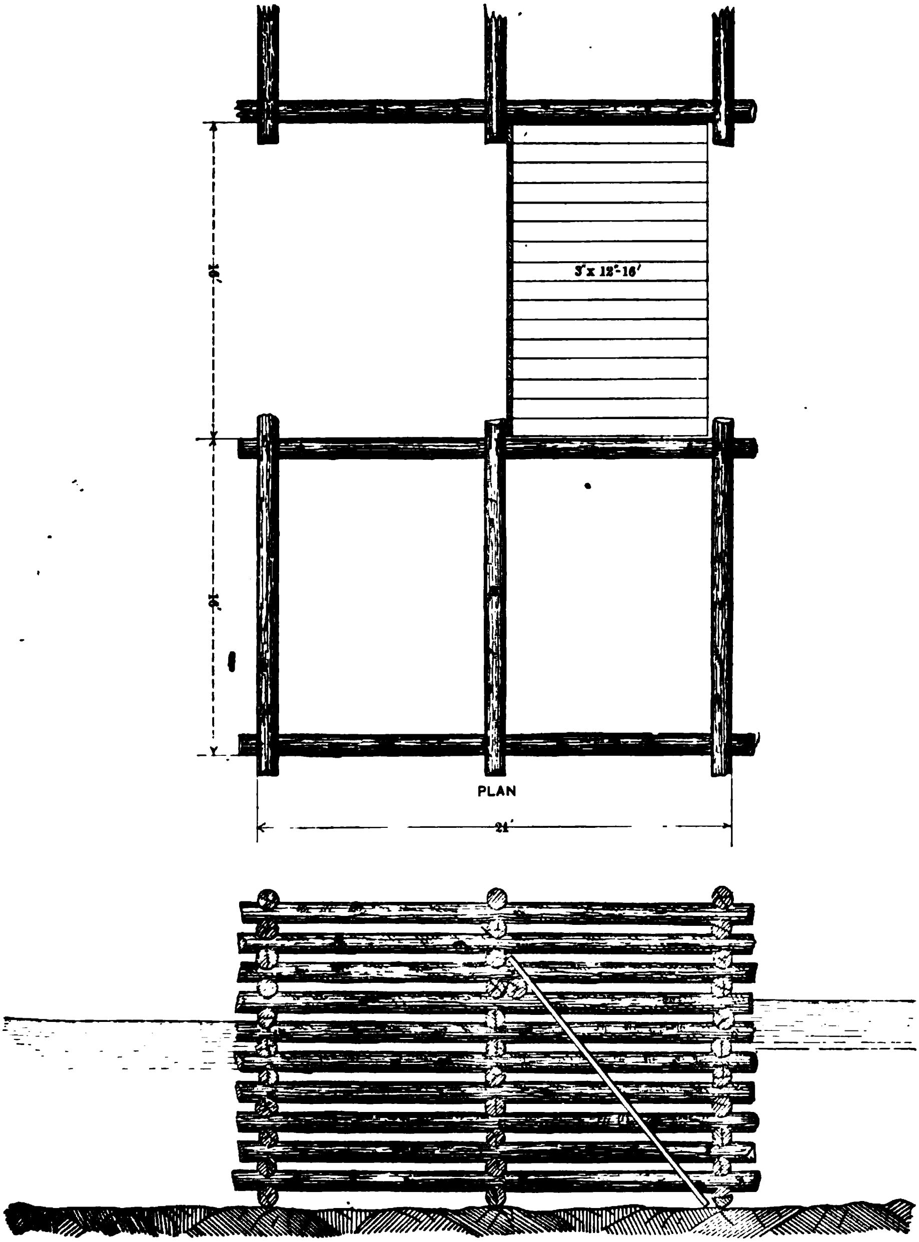


Fig. 6.

end of the barge, dropped them with the current, down to the breakwater, maneuvering so as to bring the crib to place, where it was filled with stone. The empty barge was then towed up out of the rapids. First, two anchor cribs were placed, about 400 ft. apart and 1 000 ft. above the breakwater, and then three anchor cribs, on a line parallel to and 250 ft. above the breakwater. These were used to assist in guiding and in holding the floating cribs, because, on account of the many cross-currents, the tug, 2 000 ft. away, could not locate them accurately. As soon as a crib had received enough stone to hold it against the current, the sides were built up to a height of 5 or 6 ft. above the water and it was filled with stone, making it perfectly secure. After all the cribs had been placed, the intervals were closed by 2-in. or 3-in. planking, depending upon the depth of the water.

A log, about 12-in. in diameter, was placed just above the water surface, extending between adjacent cribs, to support the upper end of the sheathing, which was laid with a slope up stream. The lower end of the sheathing rested on the bottom of the river and the current held it firmly in place. This construction is shown in Fig. 6. Where the depth of water exceeded 10 ft., it was found impracticable to close the openings with sheathing, as the planks could not be placed with sufficient accuracy, but were twisted out of the men's hands as they tried to guide them in their descent to the bottom. Several different methods of placing the planking were tried without success, and, in the deeper water, additional cribs were dropped into the intervals, making the outer end of the breakwater solid cribwork. A track, of 18-ft. gauge, was laid on top of the breakwater for the traveling derrick, which was used quite extensively, first for the construction of the breakwater and later for the coffer-dam. The breakwater served its purpose admirably, as there was practically no current below it and there was a difference of about 19 in. in the water surfaces above and below the sheathing.

The following materials were used in the breakwater:

Spruce logs,	38 291 lin. ft.
Lumber,	15 808 ft., B. M.
Drift-bolts (¾ by 20-in.),	8 100 lb.
Sandstone,	4 810 cu. yd.

The river bed, which could be plainly seen through the clear

PLATE XVII.
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FEBRUARY, 1905.
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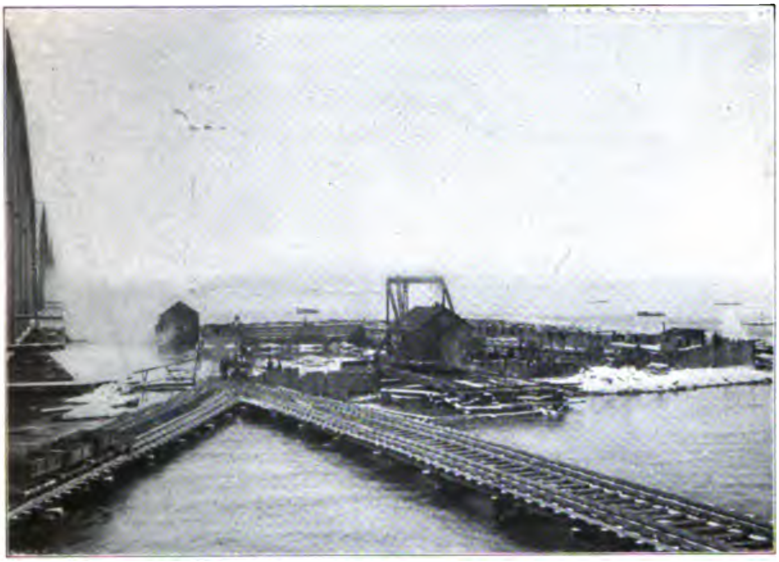

FIG. 1.—LAKE SUPERIOR COMPENSATING WORKS. COFFER-DAM PUMPED OUT. VIEW FROM SHORE, DEC. 10TH, 1901.

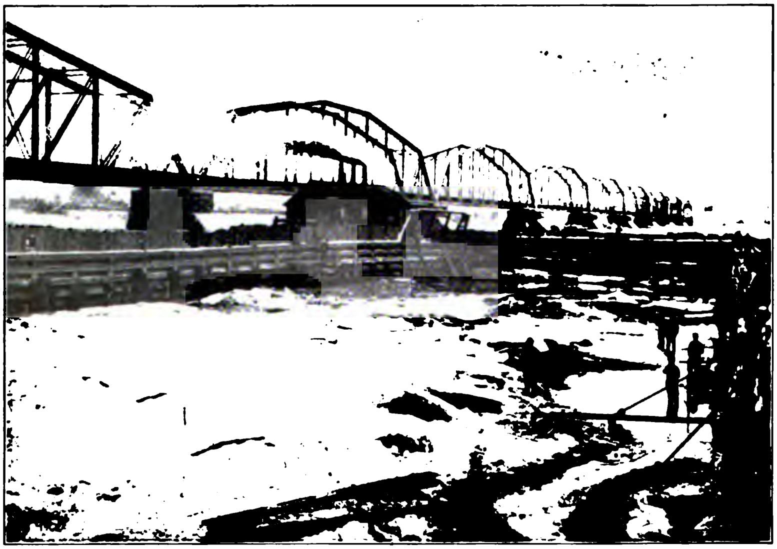

FIG. 2.—LAKE SUPERIOR COMPENSATING WORKS. COFFER-DAM PUMPED OUT. VIEW LOOKING SOUTHEAST, DEC. 10TH, 1901.

water, was smooth rock, intersected by numerous long cracks, extending in every direction. The greater part of it was swept clean by the current, but about one-half of the area to be inclosed by the coffer-dam was overlaid by a deposit of gravel and boulders which, in places, was from 6 to 7 ft. thick. On September 3d, a small dipper dredge and a dump-scow were placed behind the breakwater to remove this deposit, preparatory to the construction of the coffer-dam. Difficulties were experienced in disposing of the dredged material, as the scow could not be handled satisfactorily within the limited area sheltered from the current, and it was decided to clean the bottom along the line of the coffer-dam only, leaving the bulk of the material to be taken out later. The use of the scow was discontinued and the dredged material was cast to one side. By this method, a dike was formed, just north of where the coffer-dam would rest, extending 3 or 4 ft. above the water surface, and making an additional protection on that side. This work being completed, the dredge and the scow were removed.

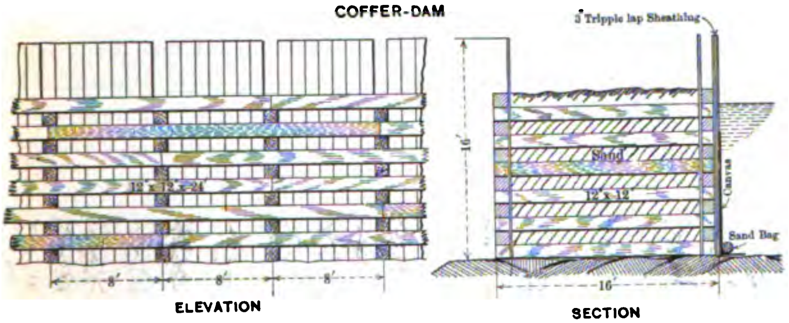

Fig. 7.

The coffer-dam, Fig. 7, was in the shape of a trapezoid, inclosing an area of 29 120 sq. ft., and measuring 900 ft. around the outside. Each of the four sides was a continuous crib of 12 by 12-in. timber, 16 ft. wide and 12 ft. high, built in place in the water. These cribs were settled to the bottom, in their proper locations, and were then connected at the corners of the dam. The cribs were sheathed inside with 1-in. plank, placed vertically, and battens were nailed over all cracks, making tight joints. Between the two walls, thus formed, sand filling was placed, to give the necessary weight to the dam. A row of tongued and grooved sheathing, made with three thicknesses of 1-in. plank nailed together, was placed around the outside of the cribs. The lower end of this sheathing was sharpened to a chisel edge, and each piece was well driven with a wooden maul, so as to broom up the lower end and make a close fit against the rock bottom. The sheathing was nailed at the top and near the bottom, a diver being employed in the operation. A strip of canvas, 5 ft. wide, was laid all around the bottom of the dam, extending up the sides for 3 ft. and out on the river bottom for 2 ft. Battens were nailed over the canvas, to hold it against the dam, and sand bags held the part in place on the bottom. A second 5-ft. strip of canvas encircled the dam above the first, overlapping it a few inches. The only purpose served by a sand filling was to give enough weight for stability, while the tongued and grooved sheathing and the canvas were depended upon to make the dam water-tight. Sand was pumped from the lake bed, near Point aux Pins, about 8 miles away, and was delivered on barges at the breakwater, where it was loaded into skips and handled by the traveling derrick either directly into the coffer-dam or into small dump-cars on top of the dam. Track was laid on the cribs, extending around the entire dam, with a turntable at each corner, so that the cars could reach all parts of the dam. The coffer-dam was commenced on September 25th and was completed on November 30th. The following materials were used in its construction:

Timber (12 by 12-in.), 264 576 ft., B. M.
Planking (1-in.), 92 252 ft., B. M.
Drift-bolts (¾ by 22-in.), 5 620 lb.
Sand, 4 986 cu. yd.
Canvas (60 in. wide), 918 yd.

A clay puddle, between the walls, would have made the triple-lap sheathing and the canvas unnecessary, but clay was not to be found in the immediate vicinity, and could not have been used, except at considerable cost, both for placing and removing it.

The pumping plant, consisting of two 12-in. centrifugal pumps, with direct-connected engines, and three 30-h-p. boilers, was installed on a small barge, which was moored at the lower side of the coffer-dam. A 12-in. rubber suction hose, 40 ft. long, led from each

PLATE XVIII.
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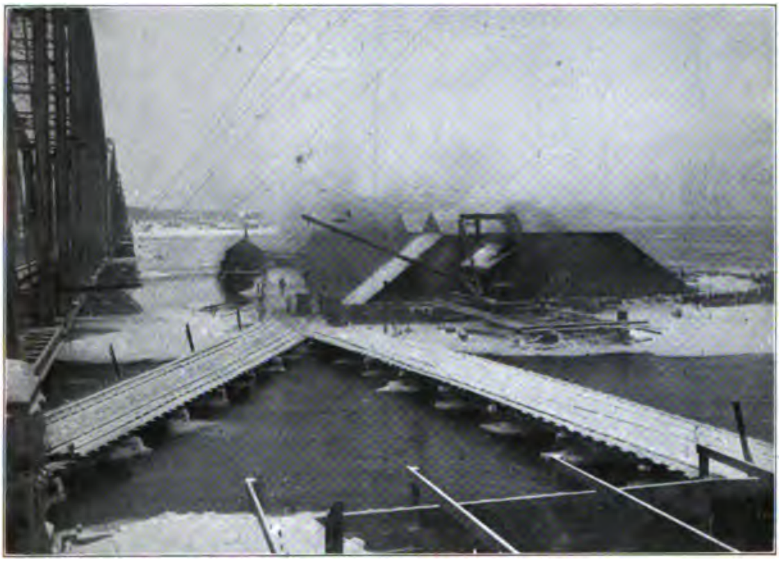


FIG. 1.—LAKE SUPERIOR COMPENSATING WORKS. VIEW FROM SHORE, FEB. 1ST, 1902.

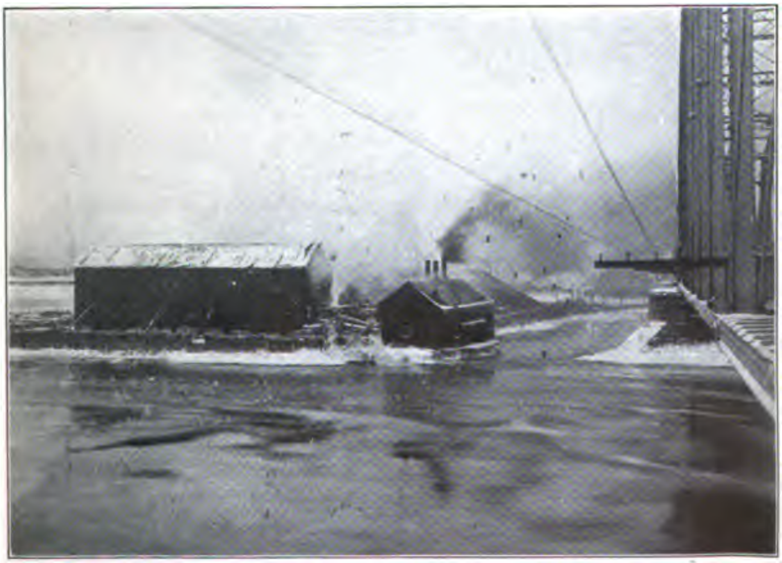


FIG. 2.—LAKE SUPERIOR COMPENSATING WORKS. VIEW FROM RAILROAD BRIDGE, FEB. 1ST, 1902

pump across the top of the coffer-dam, and 12-in. discharge pipes carried the water over the side of the barge. Each pump had a capacity of 4 000 gal. per min., with a lift of 20 ft., which was the height the water was raised. A house was built on the barge, covering and protecting the machinery from the weather. By the time the coffer-dam was completed, cold weather had set in, and there was a 6-in. sheet of ice on the water inside the dam.

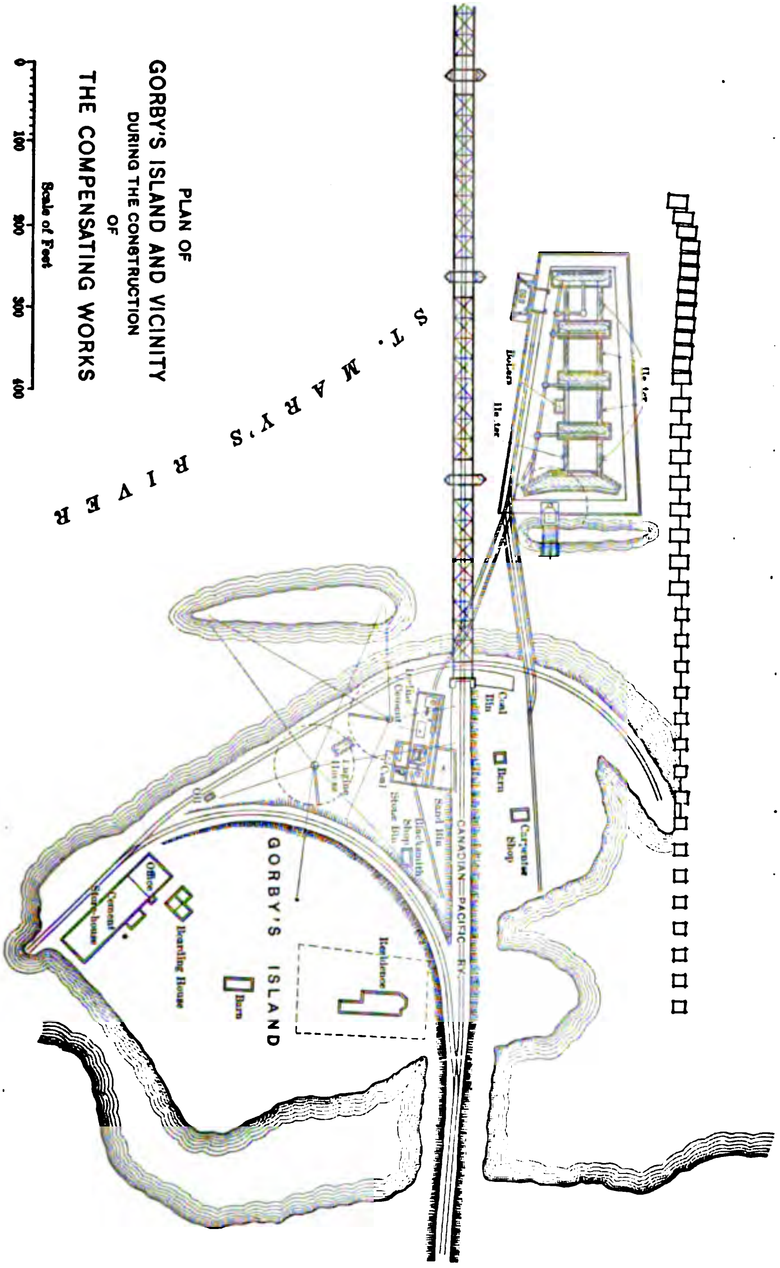
It took considerable time to pump out the dam, and when the bottom was finally exposed, it was found that several seams in the rock were spouting water. These seams were caulked with oakum, or with wedges of soft wood, which reduced the leakage very considerably, so that it could be handled easily with one pump. A sump, about 5 ft. deep, was blasted out of the rock where the suction pipes were located, and drains to conduct the water were made close to the inner wall of the coffer-dam.

The coffer-dam proved entirely satisfactory, but, on several occasions, there was some little trouble with the pumps, usually due to the neglect of the men in charge of them. On one particularly cold night, the coffer-dam was flooded to a depth of about 2 ft. by a rather unusual occurrence. The discharge pipes from the pumps projected through the house, and were not protected from the weather. They did not extend quite to the side of the barge, and, if the pump was run very slowly, some water fell on the deck, where it froze. There was always more or less ice on the deck, but it was chopped away from time to time and not allowed to accumulate. On the night in question, the pump runner did not venture out of the house, as the temperature was about 20° below zero, and the ice formed more rapidly than usual. Ice built up, in a column, from the deck to the mouth of the pipe (5 ft.) and then formed in the pipe, gradually reducing the outlet until the discharge was filled with solid ice as far back as the pump, a distance of 16 ft. As the pump kept on revolving, some little time elapsed before the discovery was made that it was not throwing water. As soon as the facts were known the second pump was put in operation and, in a short time, cleared the coffer-dam.

On December 7th was commenced the excavation of the gravel and boulders which had been left inside the line of the dam. The traveling derrick had been shifted from the breakwater to the north end of the coffer-dam, and was used in handling this material.

Tracks were laid inside the dam for small platform cars, which carried skips of about 1 cu. yd. capacity. These were loaded by hand and pushed up within reach of the derrick, which hoisted them to the top of the dam and dropped the material into small dump cars. These cars were run ashore, over a trestle, and the gravel, etc., was used in filling a part of the river, beyond the end of the International Bridge. An area of about 1 acre was thus reclaimed, and this ground was used, later, for storing structural steel for the gates. On excavating the rock, below the level of the drains, water commenced to collect in the workings, coming through the cracks and seams. Bailing and pumping with hand-pumps served, at first, in keeping the excavation clear, but, as the foundations extended and the seams opened up more and more by the blasting, the quantity of water to be handled increased. Ice formed very rapidly and was nearly as troublesome to excavate as rock.

The working force became much reduced, on account of the low temperature, and it was impossible to get men to work at night. In this contingency it was decided to erect buildings over the site and to establish a heating plant in them, so that the work could be carried on regardless of the weather. Five buildings, each 20 ft. wide, 30 ft. high, to the eaves, and of sufficient length to cover the piers and the abutment, were constructed. Between these buildings, sheds, 44 ft. wide, 40 ft. long and from 8 to 12 ft. high, were erected, the whole being connected as one building and sheltering all parts of the work. The buildings over piers were located so as to leave room for a track alongside the pier. Numerous doorways were made, and a system of tracks was laid so that materials could be taken on cars to all parts of the buildings. The buildings were covered with tar-paper, in order to retain the heat. The heating plant consisted of three 20-h-p. boilers (taken from hoisting engines) and ten radiators, made with 1 900 lin. ft. of 2-in. steam pipe, in coils. These coils were distributed around the walls of the buildings, and, with the ells, nipples, etc., gave about 1 125 sq. ft. of radiating surface. The area of the walls and roof was 41 400 sq. ft. and the interior volume of the buildings about 280 000 cu. ft. Steam was carried at a pressure of 90 lb., and no difficulty was found in maintaining a temperature above freezing, even with the outside temperature 20° below zero. The usual temperature was about 40° fahr. Numerous valves were placed in the heating coils, so that



PLAN OF
GORBY'S ISLAND AND VICINITY
DURING THE CONSTRUCTION
OF
THE COMPENSATING WORKS

FIG. 8.

connections could be made, and steam obtained, for running drills, pumps, etc., wherever needed. Light was provided by sixty incandescent electric lights, each of 16 c-p. The Tagona Water and Light Company, of Sault Ste. Marie, Ont., furnished current for these lights. The buildings were commenced on January 4th and finished on January 16th, the following materials being used in their construction:

Lumber, 88 576 ft., B. M.;
Laths (4 ft.), 12 200;
Tar-paper, 256 rolls;
Wire-nails, 20 kegs.

Fig. 8 is a general plan of the work, and shows the location of the buildings. The excavating was recommenced and continued both night and day, as there was now no trouble in getting labor. The water in the excavation was taken care of by a 4-in. pulsometer taking its steam from the heating coils.

At first, no blasting was allowed, for fear of damaging the buildings, and the rock was loosened by picks and wedges. After a few experiments, however, it was found that light charges of dynamite would not cause material injury, and blasting was again commenced. The rock was an argillaceous sandstone, which appeared to be pretty solid, but it was found to lie in strata varying in thickness from 6 to 15 in. These layers were separated by beds of hard argillaceous material, which disintegrated rapidly when exposed to the air, and became quite soft when wet. The pier foundations are from 6 to 10 ft. deep, below the original bed of the river, and the excavation for the sill between the piers varies in depth from 4 to 7 ft. Along the up-stream edge of the sill, a trench, extending to the bottom of the pier foundations, was made, to furnish drainage for the excavations. This trench was filled with concrete when the sill was laid, and forms a cut-off wall to prevent any leakage under the sill. The materials removed were:

Gravel and boulders	800 cu. yd.
Sandstone	2 708 " "
Total	3 508 cu. yd.

The concrete plant was located in a large building at the north end of the railroad bridge, alongside the tracks of the Canadian

PLATE XIX.
PAPERS, AM. SOC. C. E.
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STICKNEY ON
LAKE SUPERIOR COMPENSATING WORKS.

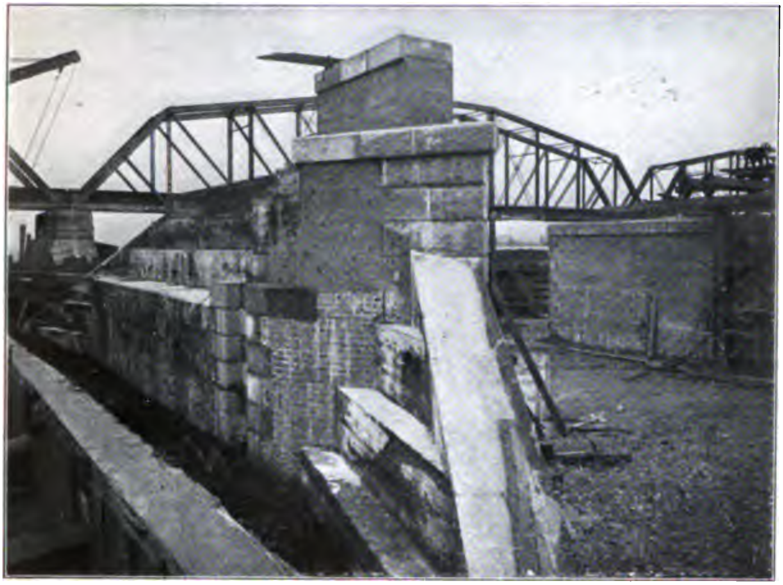

FIG. 1.—LAKE SUPERIOR COMPENSATING WORKS. ABUTMENT PIER, APR. 21ST, 1902.

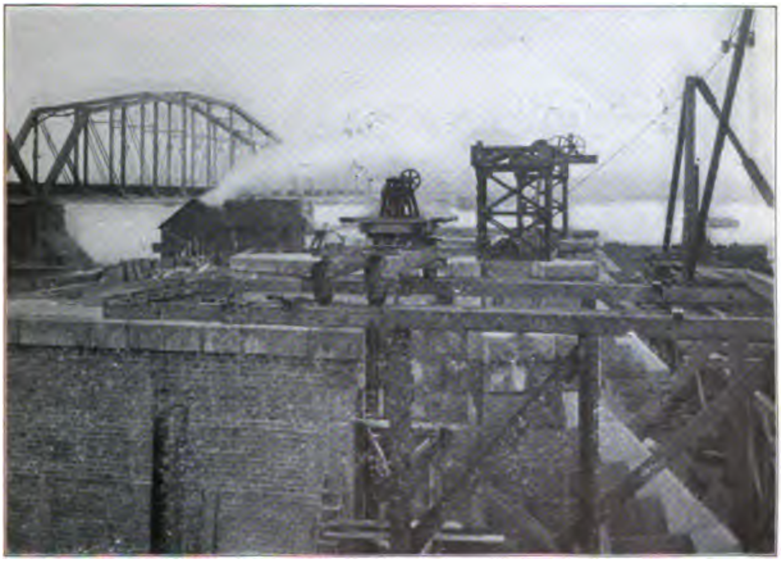

FIG. 2.—LAKE SUPERIOR COMPENSATING WORKS. ERECTING STEEL, APR. 21ST, 1902.

Pacific Railway. It consisted of a No. 6 gyratory stone-crusher and a 4-ft. cube, concrete-mixer, both of which were operated by steam furnished by a 60-h-p. boiler. The stone-crusher was set up at one end of the building and the concrete-mixer at the other. Between them there was an elevated bin, of about 100 cu. yd. capacity, for the storage of crushed stone. A belt-elevator took the broken stone from the crusher up into a rotary screen at the top of the building, where the dust was removed, and the stone dropped into the bin.

Opposite the stone bin there was a sand bin, of about 600 cu. yd. capacity, built on the slope of the railroad embankment, the latter being about 20 ft. high. A track, extending between the two bins, led up an incline to an elevated platform, in which was placed the charging hopper over the mixer. A small dump-car was used to deliver the stone and sand at the mixer, being hauled up the incline by a power hoist; and cement, in sacks, was carried to the charging platform by a belt-elevator. The car was divided by a partition into two compartments, of such size as required to measure the proper quantities of sand and stone for a batch of concrete. Sand was shoveled into the car, which was then moved to the stone bin, where a gate was opened, letting the stone drop into the car.

The sand and stone for the crusher were brought to the work on cars, and were unloaded from the main line of the Canadian Pacific Railway, the sand being shoveled directly into the sand bin, and the stone thrown down the embankment, where a pile of about 3 000 cu. yd. was accumulated.

A track led from the crusher to the stone pile, so that the stone could be loaded into a small car and dumped directly into the crusher. Steam pipes were laid through the sand and stone bins and also into the water tank, so that all the concrete materials could be warmed before mixing. A track, under the mixer, led out to the coffer-dam, over a trestle, for the delivery of concrete. Wooden boxes, with bottom doors, were used in conveying concrete. These were placed on platform cars, which ran under the mixer and received a charge. They were then run out to the coffer-dam, where a derrick picked up the box and placed it on a second car, down inside the coffer-dam. The pier foundations and the sill were divided by wooden bulkheads into twenty-four sections, each containing approximately 100 cu. yd., as this was the quantity of concrete that could be placed conveniently in one day. This concrete was mixed in the proportions, 1 part cement, 1½ parts sand and 4 parts broken stone. The water coming into the excavation required almost constant pumping, and efforts to stop up the leaks only resulted in their breaking out in new places in a short time. Various expedients were adopted to stop or divert the flow at the point where concrete was being placed. The smaller leaks were caulked with oakum, and, if this was not sufficient, a strip of canvas was hung along the face of the excavation and the concrete was placed in front of it, confining the water between the canvas and the natural rock, where it would flow until it escaped into the next section. After the concrete was raised above the leak, it would be shut off altogether. At one point, the inflow had increased to such extent that a 3-in. pipe was required to carry the water. Here a small chamber was hollowed out of the rock, to form a reservoir, into which the end of the pipe was inserted. The opening was walled up with brick, laid in cement mortar, and the water was allowed to flow through the pipe, while concrete was placed, inclosing the pipe. After allowing sufficient time for the concrete to set, the pipe was plugged.

The first concrete was placed on February 4th, and on March 3d the foundations of the piers and the sill, containing 2 113 cu. yd., were completed. The granite paving on the sill was completed two days later, having been laid as soon as the concrete had set. This paving covered an area of 880 sq. yd. The blocks averaged about 4½ by 6 by 9½ in., and laid 26 to the square yard.

Trestles were erected at each pier, to support a traveler, used in building the pier. These trestles extended the full length and width of the buildings, so that the traveler spanned the pier and the material track, alongside. The travelers were constructed as follows: A pair of trucks, each with two double-flanged wheels, was connected by two bridge pieces, on which the dolly moved. The dolly was a small platform car, carrying a hand-power winch. The center of the car platform was removed, so as to permit the hoisting line from the winch to pass through the frame.

The travelers were moved, longitudinally and transversely, by using pinch-bars under the wheels. The stone for the piers was on the ground long before the foundations were completed.

Although this stone had been quarried late in the fall, and was then stacked where it was exposed to extreme cold weather, only one

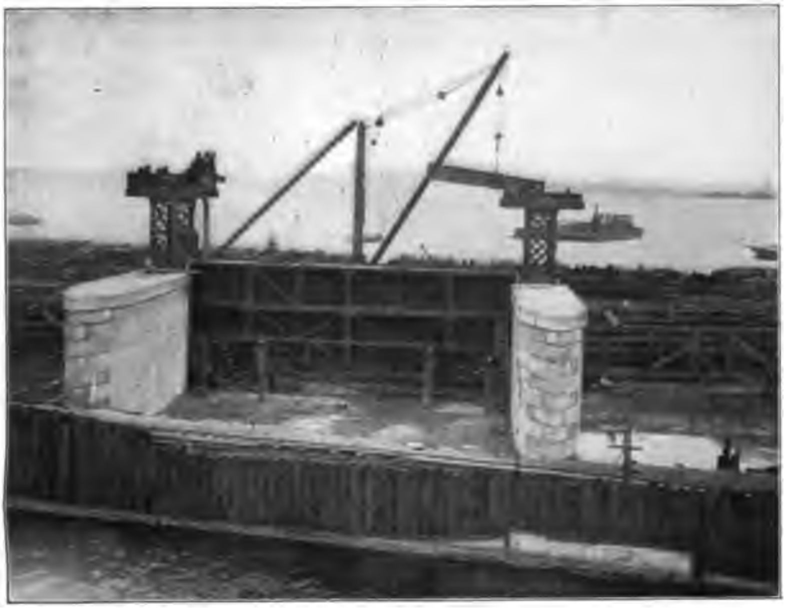

FIG. 1.—LAKE SUPERIOR COMPENSATING WORKS. STEEL GATE IN PLACE, APR. 21ST, 1902.

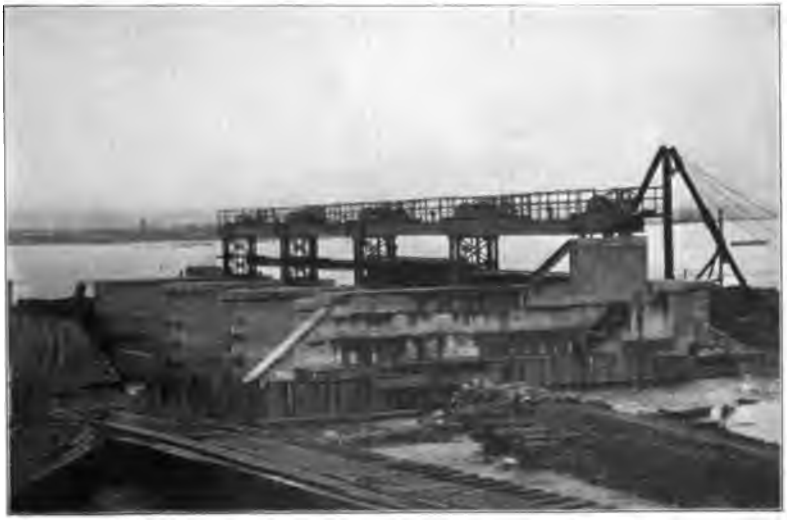

FIG. 2.—LAKE SUPERIOR COMPENSATING WORKS. NORTH VIEW OF END.

piece was lost through the action of frost. It was necessary to warm all materials before placing them in the piers, and this was done by placing them in the buildings from 18 to 24 hours before they were needed. All the dimension stone and the facing blocks, required for one course, were placed on the track, alongside of each pier. On several occasions, when it was desired to warm the stone quickly, this was done by pouring hot water over them, the water being heated, in buckets, by steam from the heating coils. The dimension stones of a course were set, and then three courses of the facing blocks were laid. Five courses of the facing blocks were equal in height to one course of dimension stone. The facing blocks averaged 4½ by 5½ by 8½ in., and laid 34 to the square yard. They were somewhat smaller than the paving blocks, and were more regular in shape and more uniform in size. The concrete backing, mixed in the proportions, 1 part cement, 2 parts sand and 5 parts broken stone, was placed as high as the facing, and then two more courses of granite blocks were laid. As no forms were used to support the facing, it was necessary to allow a certain time, usually 12 hours, for the mortar in the joints to set, before the concrete was placed, otherwise the facing would be crowded out of line. The masonry averaged 1 ft. in height, on each pier, per day, except on the abutment, where delays were occasioned by a change in plan, requiring additional stone from the quarry. The first stone was set on March 1st and the abutment was completed on April 10th. The piers and abutment contain the following classes and quantities of masonry:

Dimension stone	502.33	cu. yd.
Granite facing	150.67	" "
Concrete backing	1 252.00	" "
Total	1 905.00	cu. yd.

The materials used in the piers and sill are as follows:

Cut granite, 132.78 cu. yd.;
Cut limestone, 369.55 cu yd.;
Granite facing blocks, 26 500;
Granite paving blocks, 23 000;
Portland cement, 7 039 bbl.;
Sand, 1 477 cu. yd.;
Broken stone, 3 283 cu. yd.

The granite was obtained from St. Cloud, Minn., and the limestone came from Southern Indiana. The stone, for concrete, was quarried about a mile from the work. The cements used were "Vulcanite" and "Alpha."

The heating of buildings was discontinued on March 28th, the weather having moderated so that it was no longer necessary.

During the 72 days that the plant was in operation 292 tons of coal were consumed. The removal of buildings was immediately commenced, and was completed on April 5th. There now remained, to complete the substructure, only the setting of the roller tracks in the quoins of the piers. This proved to be a very tedious operation, on account of the large number of bolt holes drilled in the granite.

The track castings are 12 in. wide, 4 in. thick and 20 ft. long, made in two pieces, and are fastened to the masonry by two sets of bolts crossing each other at right angles, as shown in Fig. 9. The bolts had to be placed with great care, in order that the casting would slip over them, as there was very little clearance between bolt and plate. Wooden templates were made, to locate the holes, and the drilling was done by hand. The bolts, parallel to the axis of pier, were set first with sulphur, being centered with small wooden wedges and a swallow's nest of clay, placed so as to make the hot sulphur run back into the hole. The track-plates were slid over the bolts, and pulled back tight into the quoin. The transverse bolts had to be inserted through the track-plates and fastened into the holes previously drilled for them. These bolts were made with a ½-in. hole bored longitudinally through the center. They were fastened to the masonry with cement grout, pumped through the center hole, and filling the annular space around the bolt.

All materials were removed from the coffer-dam, and the pumps were stopped on April 23d, having run continuously for a period of 145 days, with an expenditure of about 595 tons of coal.

The gates were put in place by the Dominion Bridge Company, of Montreal, Que., that company having been awarded the contract to furnish and erect the gates complete, on April 12th, 1901.

The fabrication of structural steel, etc., had been completed early in the winter, and the greater part of this material arrived during February, 1902, being unloaded close to the work, to await the completion of the substructure.

On April 4th, the Bridge Company began preparations for the erection. A traveling derrick, with a small air-compressor (to operate the riveters), was installed on the west wall of the cofferdam; tracks were laid to convey the materials from the shore; and the materials were sorted and distributed within reach of the derrick.

Four trestle-bents were constructed at each opening, to support the gates above the water level during erection. The various parts were quickly assembled, the first steel being set up on April 17th and the entire structure erected by May 5th. The driving of some 6 000 field rivets delayed the completion somewhat, but all parts were finished on June 15th, 1902.

SECTION THROUGH QUOIN

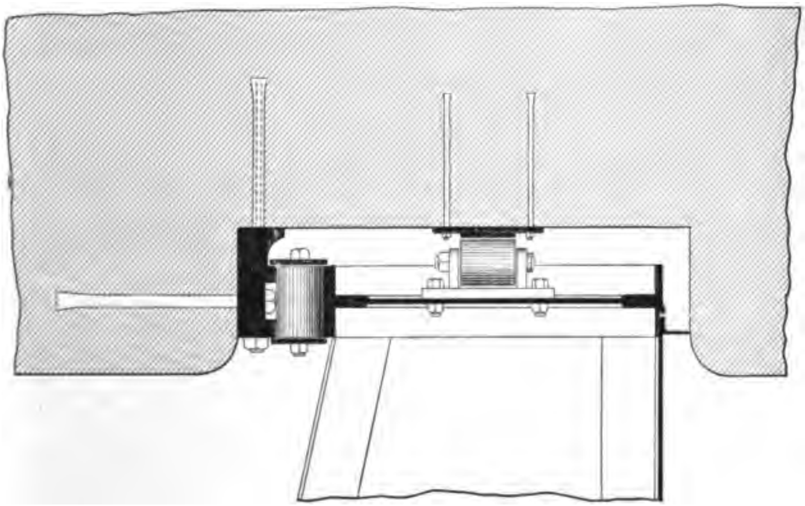

FIG 9.

The difficulties caused by the location, in swift running water, and the methods adopted for constructing masonry during extreme cold weather, made necessary a large amount of preparatory work before actual construction commenced, and added materially to the interest in the work.

Vol. XXXI. FEBRUARY, 1905. No. 2.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
INSTITUTED 1852.

PAPERS AND DISCUSSIONS.

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A RATIONAL FORM OF STIFFENED SUSPENSION BRIDGE.

Discussion.*

By Messrs. Oswald Erlinghagen, Henry W. Hodge and F. Schüle.

Mr. Erlinghagen.

Oswald Erlinghagen,† Esq. (by letter).—A comparison of Mr. Lindenthal's design for a stiffened suspension bridge with the design for a suspension bridge proposed by the Harkort Company for the second bridge over the Rhine in Cologne, is interesting, for the reason that the Harkort Company, for which the writer was Designing Engineer, made two plans for this bridge, one with cables of eye-bars, and another, of precisely the same form, with cables of wire strands of a special form, manufactured and patented by the well-known firm of Felten and Guilleaume, in Mülheim on the Rhine.

The plans were made for a competition of designs in 1898-99. No decision on the plans has yet been reached, because considerable changes in the existing steam railroad tracks on the right shore of the river, opposite Cologne, will have to be made before the bridge can be built.

Several designs of suspension structures for this bridge had

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*Continued from December, 1904, *Proceedings*. See August, 1904, *Proceedings* for paper on this subject by Gustav Lindenthal, M. Am. Soc. C. E.

† Designing Engineer for the Harkort Company in Duisburg, Germany.

Mr. Erlinghagen.

been made in former years, and, in these designs, stiffening trusses of various forms, suspended from the cables, were proposed, but it was desired that the bridge should be above the commonplace in design, and that its architecture should be suited to the historical importance of this old and picturesque city.

Fig. 9* shows the general form of the bridge and the arrangement of the wind bracing.

One of the main conditions was that the free view from the bridge, over the surrounding landscape and over the city, should not be obstructed by the bridge trusses. For that reason the supporting cables and bracing were raised high above the roadway. The upper arch line represents the cable, which supports the entire length of the bridge. The lower arch line is the bottom chord of the stiffening frame. That form of stiffening was chosen for æsthetical reasons, the designer well knowing that it would not result in as rigid a bridge as would otherwise appear desirable.

The form of stiffening in Mr. Lindenthal's design for the Manhattan Bridge, and also for the Quebec Bridge, is more rational, because more economical, and more rigid under one-sided loads.

The Cologne Bridge is intended to have only two electric railway tracks on the roadway, on which the principal traffic will be by wagons and pedestrians. Crowding on such a bridge can easily be prevented by police regulations, and therefore the question of avoiding too great deflections did not receive special consideration.

On a bridge over the East River, with eight tracks, however, as in the proposed Manhattan Bridge, subject to frequently congested traffic, the subject of rigidity is of the first importance. Police regulations against crowding and the bunching of the heavy electric cars and other vehicles on eight tracks cannot as readily be enforced as on only two tracks. It is advisable, therefore, to have the most rigid system attainable. The same is true, also, for a railroad bridge, as in the case of the bridge over the St. Lawrence at Quebec.

The form of stiffening selected by Mr. Lindenthal has the advantage that it meets that condition very economically, because it provides for the greatest depth of the stiffening trusses at the points where it is most needed, and as is explained in the paper.

The form of stiffening chosen for the design of the Cologne Bridge has also the advantage, like the Lindenthal system, of saving one chord, because the cable itself forms the upper chord. But the form of the Cologne design requires heavier cable sections at the quarters of the middle span and at the middle of the side spans, while the Lindenthal system does not require them. The amount of metal is less, proportionately, and yet the author's system is more rigid. Therein consists its rationality and economy. The writer's opinion, therefore, is that his system is particularly suitable for a

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* Fig. 9 was omitted by accident, but will be found on page 181.

Mr. Erlinghagen.

TABLE 1.—(*Continued.*)

STEEL EYE-BARS

361 FT. SIDE SPAN 361 FT.

MEMBER	STRESS	AREA
ANCHOR	t	26 à 400·25
8-0		24 - - ·22+2 à 200·22
0-1	3283	26 - - - - +2 - - - -
1-2	3661	28 - - ·25
2-3	3975	28 - - ·26+2 - - ·26
3-4	4177	30 - - -
4-5	4297	30 - - - - +2 - - - -
5-6	4311	32 - - - -
6-7	4373	32 - - ·25+2 - - ·25
7-8	4341	34 - - ·24,5
8-9	4273	32 - - ·25+2 - - ·25
9-10	4161	32 - - ·25
10-11	4025	30 - - ·25+2 - - ·25
11-12	3875	30 - - ·25
12-13	3720	28 - - ·24,5+2, - - 24,5
13-14	3560	28 - - ·24,5
14-15	3404	26 - - - - +2 - - - -
15-16	3250	26 - - ·25

722 FT. CENTER SPAN 722 FT.

MEMBER	STRESS	AREA
17-18	3144	24 à 400·24,5+2 à 200·24,5
18-19	3149	24 - - ·24 +2 - - ·24
19-20	3139	24 - - ·24,5+2 - - ·24,5
20-21	3243	24 - - ·25 +2 - - ·25
21-22	3296	24 - - - +2 - - ·25
22-23	3347	26 - - - -
23-24	3389	26 - - - -
24-25	3420	26 - - - -
25-26	3431	26 - - - -
26-27	3425	26 - - - -
27-28	3393	26 - - - -
28-29	3342	26 - - - -
29-30	3272	24 - - - - +2 - - 25
30-31	3199	24 - - - - +2 - - - -
	t	

BOTTOM CHORD OF STIFFENING TRUSS

361 FT. SIDE SPAN 361 FT.

MEMBER	STRESS +	STRESS −	AREA] ¦ [
0-1	448	394	4 L 150·150·18
1-2	432	379	2·580·18+4 L 150 150·18
2-3	858	752	4·620·18+4 L 150·18+2·300·18
3-4	1202	1057	8 620·18+4 L 150·150·18
4-5	1419	1245	8 - - - - +8 L - - - - -
5-6	1541	1354	8·620·18+8 L 150·150·18+ +4·160·18
6-7	1595	1401	
7-8	1594	1402	
8-9	1548	1352	
9-10	1435	1262	8 620·18+8 L 150·150·18
10-11	1281	1126	8·620·18+4 L 150·18+4 160·18
11-12	1095	964	6· - - +4 L - - +4· - - -
12-13	896	786	4· - - - +4 L - - +4· - - -
13-14	682	601	4· - - +4 L 150·150 18
14-15	466	411	2 - - +4 L - - - - -
15-16	251	223	2· - - +4 L 100·80·10
	t	t	] ¦ [$\mathfrak{A}_{3-4}$

722 FT. CENTER SPAN 722 FT.

MEMBER	STRESS +	STRESS −	AREA] ¦ [
17-18	203	444	2 620·18+4 L 100·80·10
18-19	380	265	2 - - - - +4 L 150·100·18
19-20	557	379	2· - - - +2 300·18+ +4 L 150 150·18
20-21	724	488	4 620·18+4 L 150·150 18
21-22	906	590	6· - - - +4 L - - - -
22-23	1071	681	6· - - +2 300·18+ +4 L 150·150·18
23-24	1224	758	8·620 18+4 L 150·150 18
24-25	1358	815	8· - - - +4·160·18+ +4 L 150 150 18
25-26	1473	855	8 620·18+4 160 18 +8 L 150 150 18
26-27	1561	873	
27-28	1623	878	8 620·18+8·160·18 +8 L 150 150 18
28-29	1665	872	
29-30	1697	876	
30-31	1716	885	] ¦ [$\mathfrak{A}_{21-22}$
	t	t	

STRESSES ARE GIVEN IN METRIC TONS (2205 LBS.)
AREAS ARE GIVEN IN MILLIMETERS (1" = 25,4 MM.)

Mr. Erlinghagen.

TABLE 1.—Cologne Bridge: Greatest Stresses for Each Member, and Resulting Cross-Section.

Diagonals								Verticals							
361 ft. Side Span 361 ft.				722 ft. Center Span 722 ft.				361 ft. Side Span 361 ft.				722 ft. Center Span 722 ft.			
Member	Stress		Area	Member	Stress		Area	Member	Stress		Area	Member.	Stress		Area
	+	−			+	−			+	−			+	−	
15-16	218	245	2 [$\frac{300\cdot100}{10\cdot16}$ + 2 300·15 + 4 115·10 $\mathfrak{D}_{12-16}$	30-31	253	264	2 [$\frac{300\cdot100}{10\cdot16}$ + 2 300 15 + 4 115 10 $\mathfrak{D}_{25-31}$	16	169	151	Idealler Stab	17	142	101	Idealler Stab
14-15	194	221		29-30	243	274		15	222	95	2 [$\frac{300\cdot100}{10\cdot16}$ + 4 ∟ 100 100 10	18	200	46	2 [$\frac{220\cdot80}{9\cdot12{,}5}$ + 4 ∟ 100 100 10 $\mathfrak{V}_{18-21}$
13-14	193	219		28-29	233	284		14	206	80		19	190	38	
12-13	191	217		27-28	213	276		13	187	64	4 ∟ 100 100 10 + 2 [$\frac{260\;90}{10\;14}$	20	179	30	2 [$\frac{200\;75}{8{,}5\;11{,}5}$ + 4 ∟ 100·100 10
11-12	184	210	2 [$\frac{300\cdot100}{10\cdot16}$ + 2 300·10	26-27	191	265		12	169	48		21	171	23	
10-11	174	197		25-26	170	248		11	149	32	2 [$\frac{220\;80}{9\;12{,}5}$ + 4 ∟ 100 100 10	22	162	15	4 ∟ 100·100·10 + 2 250·10
9-10	162	182	2 [$\frac{300\;105}{15\cdot16}$	24-25	146	228	2 [$\frac{300\cdot100}{10\cdot16}$ + 2·300 15 $\mathfrak{D}_{18-25}$	10	130	16	4 ∟ 100 100·10 + 2 [$\frac{200\;75}{8{,}5\;11{,}5}$	23	160	16	4 ∟ 100 100 10 + 2 220·10
8-9	138	152	2 [$\frac{300\cdot100}{10\cdot16}$	23-24	139	219		9	115	10	$\mathfrak{V}_{10-15}$ 4 ∟ 100 100 10 + 2 200 10 $\mathfrak{V}_{5-9}$	24	158	16	
7-8	114	129		22-23	130	209		8	98	3		25	157	21	4 ∟ 100 100 13 + 2 220 13
6-7	86	87	2 [$\frac{300\cdot75}{10\cdot10}$	21-22	129	204	2 [$\frac{300\cdot100}{10\;16}$ + 2 300 15	7	103	18		26	153	26	4 ∟ 100 100·12 + 2 220 12
5-6	118	112	2 [$\frac{300\;100}{10\;16}$	20-21	128	199		6	107	32		27	149	29	4 ∟ 100 100·11 + 2·220 11
4-5	183	167	2 [$\frac{300\cdot105}{15\cdot16}$	19-20	129	196		5	122	50		28	147	33	
3-4	248	222	2 [$\frac{300\;105}{15\;16}$	18-19	130	192	2 [$\frac{300\cdot100}{10\cdot16}$ + 2 300 15	4	137	67	4 ∟ 100·100 10 + 2·250 10	29	147	43	4 ∟ 100 100 10 + 2·220·10 $\mathfrak{V}_{22-31}$
2-3	344	304	2 [$\frac{300\cdot100}{10\cdot16}$ + 2 490 18	17-18	149	209	2 300·15 + 2 [$\frac{300\cdot100}{10\cdot16}$ + 4·115 10 $\mathfrak{D}_{17-18}$	3	161	96	4 ∟ 100·10 + 2·250·10 + 1·600 10	30	151	55	
1-2	436	383	4·520·18 + 2 [$\frac{300\cdot75}{10\cdot10}$		t	t		2	185	125	4 ∟ 100·10 + 2·440 18 + 1·600·10	31	64	•	
0-1	t	t	2 [$\frac{300\cdot75}{10\cdot10}$ + 4·530·18 $\mathfrak{D}_{0-1}$					1	203	145	4 ∟ 100·100·10 + 2·420 18 +		t	t	
									t	t	+ 4·100·18 + 1·600 10				
								0			4 ∟ 100·10 + 2·420·18 + 1·600·10				

Stresses are given in metric tons (2205 lbs.)
Areas are given in millimeters (1" = 25,4 mm.)

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suspension bridge of many tracks, which should be as rigid as it can possibly be made.

A lengthy description of the Cologne Bridge does not appear to be necessary. The system is statically indeterminate in the first degree. All the stresses were determined graphically with the aid of influence lines.

The dead load for the chain bridge was assumed at 8 tons per lin. m. (5 400 lb. per lin. ft.), and for the wire-cable bridge at 6.29 tons per lin. m. (4 230 lb. per lin. ft.).

The live load was assumed at 3.3 tons per lin. m. of each truss (2 220 lb. per lin. ft.).

Table 1 gives the greatest stresses for each member, and the resulting cross-sections.

The material for the chains was assumed to be open-hearth Siemens-Martin steel, having an ultimate strength of from 5 000 to 6 000 kg. per sq. cm. (71 100 to 85 300 lb. per sq. in.), with a stretch of 18 per cent.

Nickel-steel, with a strength 40% greater than Siemens-Martin steel, had also been under consideration, but offered no saving at the prices which then prevailed. These prices for nickel-steel were nearly three times as great as for structural steel. Since that time there has been a very large reduction in the price of nickel-steel, and also a great improvement in its quality and strength.

The alternative design for the wire-cable bridge provided that each cable should be composed of nineteen ropes, made of crucible wire of a special form. Each rope had an estimated ultimate strength of 13 200 kg. per sq. cm. (187 700 lb. per sq. in.), with a stretch of from 2 to 3 per cent. The largest tensional stress in each wire cable was 3·912 tons. A wire cable of this form offered greater certainty in the distribution of the stresses than a cable made up of parallel wires.

Steel-wire cables have the advantage over eye-bar cables of smaller weight for the same strength. But with that advantage there are some serious defects: the impossibility of inspection and careful maintenance of the interior of the wire cable; the much more difficult erection, and the higher cost of the material. The erection of the nineteen wire ropes of the form proposed by Felten and Guilleaume would, it is true, have decreased the difficulty of erection somewhat; but, on the other hand, the cable composed of eye-bars offers undisputed advantages, thoroughly tested by the experience of time. These are: The easy inspection and maintenance of the chain; the smaller cost of manufacture and erection, and the great solidity and certainty with which all parts of the bridge frame can be jointed. The greater weight of the chains has

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its effect upon the towers, piers and anchorages, but great weight, if it does not increase the cost, is rather an advantage in a bridge.

It will be noticed that the towers in the Cologne design have pin bearings, which were chosen because of the greater certainty with which the great pressures would be distributed upon the masonry piers.

It is gratifying to observe that the same thought occurred to the designer of the Buda Pest Suspension Bridge and to Mr. Lindenthal for the Quebec and Manhattan Bridges.

The comparison of the weights of the two designs is herewith given, and it remains only to state that, on the basis of these two carefully worked out estimates, there was no difference in cost between the chain bridge and the cable bridge.

Weight of Superstructure:

	With eye-bars.	With cable.
Floor and bracings....	1 770 Net tons.	1 770 Net tons.
Towers	985 " "	935 " "
Chain or cable.......	3 345 " "	1 610 " "
Stiffening truss......	1 205 " "	1 305 " "
Totals	7 305 Net tons.	5 620 Net tons.

Should a third design be prepared for the Cologne Bridge, of the same form, but with a chain of nickel-steel, there is no doubt that, at present prices for nickel-steel, the chain bridge would show a large saving over the wire-cable bridge.

From the æsthetical point of view, chain cables, because of their more solid appearance, are considered preferable. The fine and impressive lines of the two suspension bridges at Buda Pest, with double chains, bear testimony to that effect.

Among European bridge engineers, the opinion certainly prevails, and is fully justified by experience, that chain bridges are more durable than wire-cable bridges. That opinion was assigned at the time as one of the principal reasons for the choice of chain cables for the latest and largest suspension bridge in Europe, that which was built recently over the Danube at Buda Pest.

Mr. Hodge.

Henry W. Hodge, M. Am. Soc. C. E. (by letter).—Mr. Lindenthal's paper brings to the attention of the Profession many features of suspension-bridge design which differ from previous practice. Some of these features have already been adopted, and doubtless many others will be adopted, in general practice, as, in the writer's opinion, this design is a great advance in many ways over any bridge of this type which has yet been constructed.

Mr. Schüle. The discussions on this paper, thus far published, as well as the many articles on this type of suspension bridge which have appeared in the technical papers, seem to have centered almost entirely about the relative values of wire and bars for the main cables, and the question as to whether the stiffening trusses should be attached to and form part of the cables, or be made independent of the cables and placed at the floor line; and, while these are important features, they certainly do not by any means cover all the changes in practice used in the proposed design.

In the writer's opinion, the form of anchorage suggested is far better than any design thus far built, as the directions and amounts of the forces acting are clearly defined and localized, so that the masonry can be accurately proportioned and placed where it will be most effective, thereby obtaining a saving over the previous indeterminate designs of anchorages.

The hinged tower is also a great improvement over a tower intended to be rigid, as a rigid tower never fully realizes its intention, and although this hinged tower was severely criticized in the engineering publications when it first appeared, it has been adopted for the largest suspension bridge now in course of construction.

The use of a stiffening truss with maximum depth at the point of maximum bending is another important feature of this design, and, while it is not an entirely new idea, as it has been used to a certain extent in other suspension bridges, it certainly is more rational than the usual practice of making a stiffening truss of uniform depth throughout. Modern bridge designers are united in their opinion that in simple trusses of long span, the economic depth varies with the bending moment; and this principle certainly applies with equal force to stiffening trusses of suspension bridges.

The above-mentioned three features of this design are in themselves sufficient to place it in advance of any previous design, without taking up the question of relative values of bars or wire for main cables, and the consequent placing of the stiffening truss on the cable or on the floor. These last-named features seem to have brought out a most exhaustive discussion on both sides in the technical papers, and probably will never be settled to the full satisfaction of either side, though, in the writer's opinion, the final net difference, in dollars, between the two designs, for equal rigidity, would not be a very appreciable percentage of the total cost of a large suspension bridge, where there are so many other items which remain constant with either design of cable or stiffening truss, and the writer believes that an eye-bar chain can be erected more rapidly than a wire cable and will give a more rigid bridge for the same cost.

The writer does not agree with some who have discussed this paper, and who appear to consider a flexible bridge to be practically as good as a rigid structure. Rigidity is a most essential requirement for all framed structures, and (within reasonable limits) money expended to obtain rigidity is well expended. Therefore, no fair comparison of cost of two structures can be made unless both structures are of equal rigidity, as well as of equal strength. **Mr. Hodge.**

Mr. Schüle. F. SCHÜLE,* ESQ. (by letter).—The design of the Manhattan Bridge has awakened the justifiable interest of bridge engineers, as has been shown already by the discussion of this paper.

The objections raised to Mr. Lindenthal's project refer less to questions of detail than to the principles underlying the factors of safety for wire cables and chains, and to the comparison of parallel stiffening trusses for wire cables with stiffening trusses attached directly to the chains. These remarks are presented because of the great and general significance of these questions.

Up to the present time, the factor of safety of a bridge has always been determined with reference to the ultimate strength of the material used, and not with reference to the yield point of the material. The reason for this is that the ultimate strength for the same material varies only within narrow limits, whereas the position of the yield point may vary quite considerably, due to mechanical treatment, and because stresses, exceeding the lowest elastic limit of steel or iron, reduce the subsequent elongations, up to the point of fracture.

This is at once clear from the theoretical treatment of compression members, for which, indeed, the elastic limit is the danger point. For such members, the ultimate load producing fracture must never exceed the elastic limit—the yield point. The safe working load, however, is not based upon the elastic limit in tension, but upon the ultimate compressive strength of the member; that is to say, the safe working load is obtained by dividing the ultimate or breaking load by from 3 to 5, according to circumstances. That the practice of basing the factor of safety upon the breaking strength, and not upon the elastic limit, of the material prevails in the dimensioning of large suspension bridges, is clear from the proof given by Mr. Lindenthal† in the comparative check calculations of the sections for the cables and anchor bars of the Brooklyn Bridge and the Williamsburg Bridge.

A method of calculation, of course, is conceivable, which assumes the yield point of the material to be determinative for the dimensioning. But, in that case, the allowable stresses cannot be determined by means of the same safety factor for tension and compression members. On the contrary, a distinction would have to be made between parts exposed to compression, in which, as men-

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* Zürich, Switzerland.

† *Engineering News*, December 10th, 1908.

Mr. Schüle.

tioned before, buckling may lead to collapse when the yield point is reached, or in long compression members even before it is reached; and between tension members, for which even the passing of the yield point, as a rule, involves no danger, although the yield point and the ultimate strength may have been raised by artificial treatment of the material, as in wire cables. It is difficult, however, to conceive what advantage for the practice could be gained with a changed basis for the factor of safety.

A prudent constructor would require, under all circumstances, a greater factor of safety, based upon the yield point for such material, when that yield point had been raised in an artificial manner, as in wire, than for material the natural and lower yield point of which had been maintained by careful treatment.

To declare one-third of the elastic limit of the material necessary in the dimensioning of eye-bars, as in wire cables, would be equivalent to saying that all American pin-bridges built in the last decade are too weak, an assertion which nobody would advance seriously.

The proof that the usual coefficient of safety for tension members in bridges, corresponding to an admissible stress between 1:1.5 and 1:2 of the elastic limit of the material, is all sufficient, is furnished by tests, made in Switzerland, with discarded bridges, up to fracture. Among these tests the following may be mentioned:

The railroad bridge across the Emme, in Wolhusen (Switzerland), with a span of 48 m;* the railroad bridge near Mumpf (Switzerland), with a span of 28 m.; and the Erlenbach Railroad Bridge, near Bilberach-Zell (Baden), with a span of 19 m.

The first two bridges failed solely in consequence of the bending of a web compression member; the third bridge failed in consequence of the bending of web compression members and of the subsequent shear of rivets in the tension members of the end panels. Such tests show that the danger is not so much with tension members, insufficiently proportioned, as with compression members; therefore, a greater factor of safety for tension members does not appear to be justified.

The purport of stiffening the cable or the chain by suitable trusses is to transmit to a greater length of the cable, or of the chain, the deformations from local or concentrated loads. These deformations are partly due to the change in the equilibrium of the cable or chain from such loads, and partly due to the elastic alterations in the length of the cable, or of the chain, from the inner forces.

The first cause of the deformation is approximately the same for chain and cable, but the second cause is essentially greater for the wire cable. Consequently, the heavier chain can be stiffened more easily than a wire cable of the same span and deflection. This holds true for statically determinate stiffening trusses with a center hinge, and still more so for a stiffening truss without a center hinge. Mr. Schüle.

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* "Rapport sur les Épreuves de Charge jusqu'à Rupture de l'ancien Pont sur l'Emme à Wolhusen." Berne, 1895.

In the former case, the sections of the stiffening truss are determined by its depth, and any arbitrary reduction and variation from this rule requires the regulation and restriction of traffic.

In the second case, the dimensioning of the stiffening truss without a center hinge can be done with somewhat greater freedom, but only under the condition that non-uniform distributed loads shall be limited in intensity, so that the deflection and unit stresses caused by them shall be within the allowable stresses of the material.

The direct use of the cable or chain as a chord of the stiffening truss means, under all circumstances, a saving, (1) on account of the omission of a chord of the truss, (2) on account of the great height (in Mr. Lindenthal's design) at the quarters of the center span, and (3) on account of the small depth of the truss in the middle of the center span and the consequently smaller stresses from temperature changes.

For the purpose of comparing the different stiffening systems for the same bridge, minute calculations of the deformation are, before all things, necessary, and the publication of this paper shows that the scientific treatment of such problems, which was not possible some years ago, is now achieved, although requiring much labor.

The direct stiffening of the chain, as in Mr. Lindenthal's design, met, until a few years ago, with the theoretical difficulty that an analysis of the forces in the truss, which would be free from objections, could not be made. This difficulty is now removed, not by the application of mathematical hypotheses, but by the proper application of methods, which, for various structures of modern times, have proved to be true, and without which hardly any statically indeterminate construction of importance will be dimensioned and executed in the future.

Vol. XXXI. FEBRUARY, 1905. No. 2.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PAPERS AND DISCUSSIONS.

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METHODS OF LOCATION ON THE CHOCTAW, OKLAHOMA AND GULF RAILROAD.

Discussion.*

By Messrs. E. Sherman Gould, Wilford A. Thompson and S. Whinery.

Mr. Gould.

E. Sherman Gould, M. Am. Soc. C. E.—From the point of view of practical railroad engineering, the speaker is inclined to rate this paper very highly.

The proper location of a railroad is a matter of the greatest importance, for it affects, not only the immediate cost of construction, but that of operation and maintenance for all time, and any material change in the location of a road in active use is most difficult and expensive. In the words of the late Arthur Mellen Wellington, M. Am. Soc. C. E., the skill of the railroad engineer is shown by the imposing bridges, the high embankments, deep cuts and long tunnels which are not to be found on his line. Certainly, in skilful hands, material can be taken out more cheaply with transit and level than with the steam shovel.

The first thing in the location of a railroad is the collection of

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*This discussion (of the paper by F. Lavis, Assoc. M. Am. Soc. C. E., printed in *Proceedings* for December, 1904), is printed in *Proceedings* in order that the views expressed may be brought before all members of the Society for further discussion.

Communications on this subject received prior to March 25th, 1905, will be published subsequently.

data by means of a survey; the inferences and conclusions to be drawn therefrom come later. The survey cannot be too complete, and Mr. Lavis well says that in his experience the completeness of the survey is apt to vary directly as the completeness of the outfit, and proceeds to describe such an outfit as he has found necessary to successful work under given conditions. Many of the minutiæ may excite a smile from some of the "old war horses" as indicating, in their opinion, a too great preoccupation with the refinements of civilized life, but there can be no doubt that more and better work can be done in the field, and with a heartier spirit, when these little comforts are supplied. Mr. Gould.

Mr. Lavis begins at the beginning, with a list of the camp equipment furnished by the road with which he was connected. In glancing over this list the only point calling for criticism which met the speaker's eye is the German silver table service. He would entirely condemn the use of this metal for any use which brings it in contact with food.

All the camp regulations described seem to be sound and intelligent. Evidently, they were efficacious in securing that very difficult desideratum when in camp, namely, an early start. Nothing is said about it, but doubtless there were rules regarding the occasional airing of bedding, particularly as the men were required to make up their cots for the night immediately on rising, or at least before going to breakfast. Casually, the difficulty of procuring fresh meat and vegetables is mentioned. By a fortunate provision of Nature, salt meats suit the taste of those living in the open air much better than fresh, for a steady diet, and the same may be said in regard to the absence of milk and even sugar in one's tea and coffee. The palate seems to crave, in such conditions, the simplest and crudest flavors.

Naturally, the principal interest centers upon the engineering rather than the culinary features of the paper. The desiderata in the present case, or the objects for which the survey was undertaken, are enumerated under five headings, the second one containing the kernel of the whole proposition, namely:

"To be sure that the line obtained was such that no other line could be built through the same country with the same or better ruling grades, with less expenditure, at the same unit prices."

This sentence very neatly expresses the object of all such surveys.

Perhaps the most important feature of the paper, and the one most likely to provoke discussion, is the insistence with which the author dwells upon the superiority of a paper location over a field location, that is to say, the taking of the ground into the office, and locating the line there, more or less mathematically, rather than doing it entirely by eye, upon the ground. If the speaker is not mis-

Mr. Gould. taken, this idea was carried to the limit in the case of the Lyons and Geneva Railroad, in France and Switzerland, by the construction of a plan in relief, reproducing in miniature the whole stretch of intervening country over which the road must pass, and locating the line upon it. The increasing effort to bring the field work into the office in all branches of engineering is a marked characteristic of the present trend of practice in America. While this may degenerate into "easy-chair engineering," when carried to excess, the speaker is inclined to believe that, in the case of the final location of a railroad, or other line, the getting of full details of the topography laid down upon a contour map is the true way to secure the best results. One point, however, has perhaps not been sufficiently dwelt upon in this paper, which is, that after the line has been thus located on paper and transferred to the ground, a final revision is absolutely necessary, by the best locating talent in the outfit, which will probably result in changes of greater or less importance. Indeed, it appears to the speaker that the whole process of scientific location, from the first examination of the territory as shown on the atlas map, down to setting the final slope stakes, is one of "trial and error," from field to office, and from office back again to the field. It also appears to him that, except in those cases where there is almost no choice to be exercised, the skill and experience of the locating engineer are best shown in the rapid comprehension of the broad features of the problem, rather than in elaboration of details. The qualities which enable an engineer to take this almost instinctive grasp of the possibilities of a wide and varied stretch of territory seem to be akin to those which characterize a great military commander in his selection of strategic points. The gift may be greatly cultivated, but, for its fullest power, it must be inherent in the individual. It is also the opinion of the speaker that the value of this gift may be over-rated, and that when time allows—and if the surveys be promptly commenced instead of being relegated to the last moment, time generally will allow—no amount of "eye for the country" can supersede the patient and exhaustive instrumental examination of all the possibilities of the territory. At any rate, it is certainly safe to give to younger members the advice not to rely upon the fancied possession of this gift, but rather to cultivate the eye and judgment by painstaking study and observation.

In the present case, the necessity of exhaustive preliminary lines, previous to final location, was evidently realized, for Mr. Lavis says:

"Instructions were given the locating engineers to spend all the time necessary on investigations, to be sure they had the best line through the country traversed before putting in the location, on the ground."

It is certainly vain to cross-section a strip 800 ft. wide on both

Mr. Gould. sides of a radically vicious line, when a 5-mile swing to the right or left would open up a practicable route through easy country. That is to say, it is useless to try to make the best of a bad line, when a good one is ready to the hand.

In regard to the instrumental work, the running out of all tangents to an intersection is sound practice, unless a curve is finally adopted which sweeps in several changes of direction, when the total deflection between the points of curvature becomes the true angle of intersection. In such case it might not be necessary to produce the tangents to an apex, but, in all cases, as the author states was done, the position of the P. C. and P. T. should be calculated and the hubs set from the apex, or by long chords or otherwise, before the curve is swung in, even at the cost of much additional labor. When the curve is run on final location, if a satisfactory connection is not made with the previously established P. T., the transit should be set up upon it and the curve run backward until the discrepancy is worked out, or the existence of an error is detected.

No mention of easement curves seems to have been made in the paper.

The speaker is free to confess that he does not like the form of transit notes used in this survey. His own invariable practice has been to have two columns for deflections, left and right, and to carry the balance over from page to page. In this way, by applying the balance to the first course of the survey, the calculated course can be checked at any given station. Distances should be added up and carried forward in a similar way, so as to check them with the numbering of the hubs. In reading angles, both verniers should be read, when, if the graduation of the limb runs from 0° to 180°, as is usual, the sum of the two readings should always be 180°, thus affording a perfect check upon the recorded angles.

Mr. Thompson. WILFORD A. THOMPSON, JUN. AM. SOC. C. E. (by letter).—The writer desires to ask Mr. Lavis why the plane-table is not used in sketching topography for railroad location? Of course, many engineers think the plane-table is very inaccurate and slow, but the writer has used this instrument, in work for the United States Geological Survey, in the West, and has run lines ranging in length from 1 to 15 miles in a day, at the same time sketching the topography for ½ mile on each side of the line. These surveys were on a scale of 1 in 90 000, with a 20-ft. contour interval, and the writer is sure that, with a plane-table, a topographer can make a more accurate map in the field, where he can see the country, than can the draftsman from the best of notebook sketches.

With the stations on the line to give the lengths of base lines, and from the elevations given by the levelman, a very accurate map

Mr. Thompson. of a section 2 000 ft. wide can be made almost as rapidly as the levelman can cover the ground.

Starting at a given station and orienting on the line, short lines should be drawn to all houses, lone trees, fence corners or other objects which can be recognized from some of the next succeeding stations, such points being chosen as will be useful in locating the topography. In passing to the next station the instrumentman should note carefully the topography passed over, and after setting up should intersect objects at which shots were taken at previous stations. Distances can be scaled from the map of the intersected points, and their elevation can be found very accurately by the vertical angles. In almost any country a sufficient number of points can be located to indicate the drainage, the "backbone of topography." Having located these points and ascertained their elevations, it is a simple matter to sketch in the intervening topography.

The chief advantage is that when the topographer returns to camp the map is ready for use, and there is no necessity for waiting for hours while the draftsman works up an inaccurate map from the notes.

A rapid method of finding the elevations of intersected points is what is called the "stepping-up method." Knowing that the interval between the cross-hairs is proportional to the distance, then if the distance to a point scales 550 ft. from the instrument the interval intercepted by the cross-hairs is 5.5 ft. The alidade is leveled and the point where the upper cross-hair strikes the ground is noted. The elevation of this point, then, is one-half the cross-hair interval (very closely), or 2.25 ft. above the instrument. Then elevate the telescope until the lower cross-hair intersects the point formerly covered by the upper cross-hair. A number of these steps may be taken. If the upper cross-hair coincides with the ground at the intersected point after two steps, then the elevation at that point is two and one-half times the cross-hair interval, or 13.25 ft. above the instrument. Then, adding the height of instrument gives the difference in elevation between the ground at the plane-table and at the intersected point. This method is subject to a slight error, but, for short distances, it is far more rapid and accurate than pacing and using a hand-level. Even if there is an error of 1 ft. in the elevation of a point 1 000 ft. from the line, it is within the limit of error of a location survey, and is closer than a hand-level elevation. The writer has run lines 10 miles long, using a stadia rod for distances and reading the elevations to the nearest foot by the foregoing method and has closed without error.

With a long bubble on the telescope, and with cross-hairs close together, or an extra cross-hair between the middle and upper cross-hairs, the writer is sure that the plane-table would be most useful on location surveys. Such a table should be about 22 by 24 or 30 in., and the tripod should be light. On the under side at each end there should be rollers to carry a strip of drawing paper, 20 in. wide. If the line runs too close to the edge of the paper a new point can be taken near the other edge. Mr. Thompson.

Mr. Whinery. S. Whinery, M. Am. Soc. C. E. (by letter).—The method of locating railroads described in this paper is quite different from that in which some of us had the good fortune to "assist" (with an axe or a flag-pole), in our younger days. The up-to-date way is only scientific; the old way belonged to a higher order—it savored of Genius. The new way accomplishes results by plodding and platting; the old one reached conclusions with something of the swiftness and certainty of Instinct. The new locating engineer is merely an educated ordinary individual, and is compelled to work things out; the old one, like the poet, was born, not made—he simply came, saw, and conquered. Given, a correct topographical plat of a hillside, a set of curve-models and other paraphernalia, any of us with a reasonable share of ability can locate on the plat a curve that will best fit the topography, and, later, can transfer the curve to the ground. But, disdaining plats, to approach the hillside boldly with your line in hand, to take in at a glance the P. C., and the degree of a curve that will fit the hill comfortably, and, at the proper point on that curve to sail off on a tangent that will strike the bull's-eye 2 miles away, that was the work of a Genius. Even if it was sometimes necessary to "cut and try" a little, the line "got there" with celerity and no little success.

If this is an exaggerated picture, it must be admitted that there is more than a grain of truth in the chaff. The earlier locating engineer who attained eminence in his calling had, undoubtedly, a peculiar natural aptitude for his work. His "organ" of locality was large. He was a born woodsman, and never got "lost." His natural faculties were highly trained, because he depended upon them and not on any such auxiliary devices as are now used. His "off-hand" judgment of topography, and the grades and curves that would fit it, was more acute and accurate than that of his degenerate successor, because the latter is not compelled to rely so largely upon his unaided faculties.

All this may be admitted and yet it can be maintained successfully that, upon the whole, the new method is better than the old. It reduces the work to a system, and the results, if less brilliant, are more certain and reliable, and at least equally expeditious.

While details may differ, the paper describes well the approved modern method of railroad location, and the fullness of details makes it a very valuable contribution to the literature of the sub-

Mr. Whinery. ject. Conditions, of course, may modify the procedure. The lines, the location of which is described in the paper, seem to have been, from the start, destined for construction; roads were to be built between certain points, and the only question was to find as quickly as possible the best route and location. If, as often occurs, preliminary lines were to have been run out for the purpose of determining the practicability of the route for a railroad, the building and even the final location of which, later, depended upon the success of the promoters in financing the enterprise, the methods and means would doubtless have been somewhat modified. The outfit would not have been so complete. The promoters would have wanted to show a reasonably good line and a profile that would at least fairly represent, if not minimize, the difficulties to be overcome, and their demand could not well be ignored.

But, assuming that the office of the preliminary line is mainly, as it should be, to determine distances and elevations, and to furnish a base from which to obtain correct topography, the appearance of the preliminary profile may well be disregarded.

In running such preliminary lines, the most important and responsible position in the party, next to the Chief, is that of topographer, and it is also the most difficult to fill. The work of the linemen and the draftsman, while, of course, it must be accurate, requires no special ability; but the topographer must be an expert at his work. He must possess, in a large degree, the peculiar gifts of the old locating engineer, must have a keen eye and a good judgment for locality, distance and elevation. If he depends too much on the tape-line and the hand-level, and lacks discrimination as to the relative importance of topographical features, he will neither be able to keep up with the party nor do his work satisfactorily. Particularly must he have the ability, natural or acquired from experience, to judge of the relative importance of the topography he sketches. He must know at a glance, from the general lay of the country, that the final location will hug this hillside closely, and its topography, therefore, must be taken accurately, while that other will not be touched, and, therefore, may be sketched with less care. A poor topographer is somewhat worse than useless, while a superior one is cheap at almost any salary.

There seems to be little to criticise in the conduct of the work described by the author. Not many engineers have been as fortunate, in having employers who appreciated the value and economy of complete equipment and liberal provision for the comfort of the men. The absence, from the equipment, of the medicine chest is noticeable. The writer has always considered it of importance to have along with the party a small supply of simple or standard remedies and surgical appliances, which every intelligent person knows how to use.

Mr. Whinery.

In running out the final location line, some modifications of the method described in the paper have been found advantageous in the writer's work. They are not new, and may not be novel, but he has not seen them described in print, and they may be of some interest to other engineers.

In the summer of 1880 the writer had charge of the preliminary and location surveys for the northern half of the New Orleans and North Eastern Railroad, his work extending from Meridian, Miss., southward about 100 miles. With some alternative routes, about 120 miles of located line was put on the ground. The preliminary surveys were made with care, especial attention being given to accuracy of instrument work and chaining, and to taking the topography. The lines crossed the drainage system of the country diagonally. The streams had flat and rather wide valleys, separated by dividing ridges from 80 to 150 ft. high, with rather abrupt and broken slopes. No special effort was made to get good preliminary profiles, the object being, while keeping the line reasonably near the probable located line, to run the preliminary where it could be gotten through easiest, or would best serve the purpose of the topographer. The preliminary lines were carefully platted by the "Latitude and Departure" method.

In running the final location line, the object sought was to do as much of the work as possible in the office tent, confining the work of the party largely to putting in the stakes on the ground, from notes furnished to the transitman (who had charge of the party).

The method of procedure was as follows: A tentative location line was put on the map as carefully as possible, and its profile was platted on the preliminary profile from the topography. Very full notes were made of the relation of the located line to the preliminary, such as intersections, distances at right angles from the preliminary line, etc., using the actual and projected stations on the two lines. With these notes and the profile, a tape-line and hand-level, the writer, with an assistant, then went over the ground, noting at every controlling or important point the correspondence of the projected profile with the ground, and any changes that seemed necessary or desirable. Returning to camp, the projected location was carefully revised in accordance with the notes thus taken. This done, the courses, curves, etc., of the revised line were computed or measured with great care, and a full and accurate description made out for the use of the transitman, including very full reference notes to points on the preliminary. All this work was kept well ahead of the transit party. As long as the location line conformed to the reference notes, with relation to the preliminary line, the transitman had nothing to do but stake out the projected line. But if any divergence was noted, it was his duty to introduce such

Mr. Whinery. possible modifications as would maintain the relative positions of the two lines. Thus, after running out a tangent, say, 1 500 ft. long, to a projected P. C., if he found this P. C., came ahead of, or short of the preliminary station opposite which it should be, he moved the P. C. to its proper position and began his curve. If he found himself nearer to or further from the preliminary line than he should be, he could usually so modify his P. C. and his curve angle as to throw the succeeding curve where it should be. Fortunately, the transitman was a very competent man, and handled these small corrections very skillfully.

The results were very satisfactory, and the located line was carried forward rapidly. Occasionally, when the profile of the day's work was made up, it would not be satisfactory, and part of the line would have to be re-run the next day; but this going back was so unusual that it came to be considered by the transit party as a reproach upon the office work. The average progress made was somewhat more than 2 miles per day, which, considering that the country was mostly covered with timber and underbrush, and the hill slopes rough, was regarded as very good work. The accuracy with which the located line could be projected was sometimes surprising. At one place there was a 7-mile tangent, and as it all lay through a timbered and brushy country, special care was taken at its beginning to lay its course accurately, so as to avoid the possibility of having to re-run it. Whether due to careful work or to good luck, it came out within 20 ft. of the point intended, and this difference was readily compensated for in the succeeding curve.

The fact that all the curves were begun and ended with spirals made the work a little more complicated than usual. (As far as the writer knows, this was the first railroad in the country to be originally located with spiralized curves.)

The noteworthy variation from ordinary practice in this work was the careful review, on the ground, of the projected location, and revision before the line was actually staked out, a practice which proved so advantageous that it is strongly recommended.

The same general method was used successfully, under very different conditions, in the location, a few years later, of the "Standard Gauge" Railroad, up Lookout Mountain, at Chattanooga. Here, the line ascended the rough and steep sides of the mountain to an elevation of about 1 300 ft., on a grade of 3½%, absolutely continuous, except as modified by compensation for curvature. In this case the preliminary line was plotted on a scale of 100 ft. to 1 in.

As a rule, both money and time may be saved in the preliminary surveys by careful and thorough reconnaissance, which should be made by the engineer who is to be in charge of the work, before the party is started. Equipped with such land-office and other maps

Mr. Whinery.

as are obtainable, a skeleton map on a scale of 2 in. to the mile for sketching, and the usual outfit of pocket instruments (a good ous lengths of step of man and horse), the best probable line can a pedometer which can be set to read miles and fractions for various lengths of step of man and horse), the best probable line can usually be determined definitely before the party starts. The use of these pocket instruments is not always as well understood and as fully availed of as it should be. This is particularly true of the aneroid. So much has been written on the proper use of this invaluable instrument that it need not be repeated here. The writer has always read the inch-scale rather than the altitude scale, using for reduction to altitude, a table of "height in English feet of a column of air corresponding to one-tenth of an inch in the barometer at different temperatures and elevations." This table may be found in most treatises on hypsometry,* but it is not usually sufficiently extended for convenient use. A more extended table (Table 1), which will be found sufficient for the engineer's ordinary purposes, is appended. To illustrate its use, suppose the following observations are taken:

At the lower station, Barometer 29.20 in., Thermometer 55°
At the upper station, " 29.00 " " 50°
The tabular number corresponding to the first reading is..94.5
The tabular number corresponding to the second reading is..95.1

Average 94.8

This is the average elevation corresponding to a difference of 0.1 in. in the barometer, and this multiplied by the difference in barometer readings, two-tenths, gives 94.8 × 2 = 189.6 ft., for the difference in elevation of the points of observation. While not absolutely correct, this method is more nearly so than any other equally simple. To overcome the principal source of trouble in the use of the barometer—its normal changes with the weather—the writer has used one or two simple and fairly satisfactory methods. These changes are usually quite regular and progressive. If, with the barometer hung up, readings be taken when the user first wakes up in the morning, and again after breakfast when he is ready to start out, and similarly when he stops an hour at noon for lunch and rest, some idea of the rate of change can be formed, and applied to correct the forenoon and afternoon observations in the field. For further and final correction, at the end of the trip, the records of

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*See, for instance, "Smithsonian Meteorological and Physical Tables" by Prof. Guyot.

Mr. Whinery. the nearest weather bureau station may be applied, or, better still, those of a special barometer left at a permanent station and read by an assistant every hour of the day during the period.

It is rather common to sneer at the value of the barometer for such reconnaissance work, but when used with proper care, it is a most useful and reasonably reliable instrument. In a reconnaissance made by the writer, extending over about ten days, in the mountains of North Carolina, three aneroids were carried by the party, and at all important points the mean of their readings was used. For final corrections the mean of the barometer records of the weather offices at Knoxville and Atlanta was used. The results, when tested by actual levels, were remarkably satisfactory. The pedometer, used with judgment based on experience, is also a most valuable auxiliary on reconnaissance. Good reconnaissance work can only be done on foot or on horseback, but, in the latter case, provision must be made for having the horse led "around" on a considerable part of the trip. Except for a hasty trip to get the general lay of the country, a vehicle is useless; and fairly good maps may usually take the place of such a trip.

TABLE 1.—HEIGHT, IN FEET, OF A COLUMN OF AIR CORRESPONDING TO A TENTH OF AN INCH IN THE BAROMETER AT DIFFERENT TEMPERATURES AND ELEVATIONS.

Barometer Reading in inches.	Temperature of the Air, in Degrees, Fahrenheit, Exposed Thermometer.																
	15°	20°	25°	30°	35°	40°	45°	50°	55°	60°	65°	70°	75°	80°	85°	90°	95°
27.8..	90.9	91.9	93.0	94.0	95.1	96.1	97.2	98.2	99.3	100.3	101.4	102.4	103.5	104.5	105.6	106.6	107.7
27.9..	90.6	91.6	92.7	93.7	94.8	95.8	96.9	97.9	99.0	100.0	101.0	102.1	103.1	104.2	105.2	106.3	107.3
28.0..	90.2	91.2	92.3	93.3	94.4	95.4	96.5	97.5	98.6	99.6	100.6	101.7	102.7	103.8	104.8	105.9	106.9
28.1..	89.9	90.9	2.0	93.0	94.1	95.1	96.2	97.2	98.3	99.3	100.3	101.4	102.4	103.4	104.5	105.5	106.5
28.2..	89.6	90.6	91.7	92.7	93.7	94.8	95.8	96.8	97.9	98.9	99.9	101.0	102.0	103.0	104.1	105.1	106.1
28.3..	89.3	90.3	91.4	92.4	93.4	94.5	95.5	96.5	97.6	98.6	99.6	100.6	101.7	102.7	103.7	104.7	105.8
28.4..	89.0	90.0	91.1	92.1	93.1	94.1	95.1	96.1	97.2	98.2	99.2	100.2	101.3	102.3	103.3	104.3	105.4
28.5..	88.6	89.6	90.7	91.7	92.7	92.8	94.8	95.8	96.9	97.9	98.9	99.9	101.0	102.0	103.0	104.0	105.0
28.6..	88.3	89.3	90.4	91.4	92.4	93.4	94.4	95.5	96.5	97.5	98.5	99.5	100.6	101.6	102.6	103.6	104.6
28.7..	88.0	89.0	90.1	91.1	92.1	93.1	94.1	95.2	96.2	97.2	98.2	99.2	100.2	101.2	102.2	103.2	104.2
28.8..	87.8	88.8	89.8	90.8	91.8	92.8	93.8	94.8	95.8	96.8	97.8	98.8	99.8	100.8	101.8	102.8	103.8
28.9..	87.4	88.4	89.4	90.4	91.4	92.5	93.5	94.5	95.5	96.5	97.5	98.5	99.5	100.5	101.5	102.5	103.5
29.0..	87.0	88.0	89.1	90.1	91.1	92.1	93.1	94.1	95.1	96.2	97.2	98.2	99.2	100.2	101.2	102.2	103.2
29.1..	86.8	87.8	88.8	89.8	90.8	91.8	92.8	93.8	94.8	95.9	96.9	97.9	98.9	99.9	100.9	101.9	102.9
29.2..	86.5	87.5	88.5	89.5	90.5	91.5	92.5	93.5	94.5	95.5	96.5	97.5	98.5	99.5	100.5	101.5	102.5
29.3..	86.2	87.2	88.2	89.2	90.2	91.2	92.2	93.2	94.2	95.2	96.2	97.2	98.2	99.2	100.2	101.2	102.2
29.4..	85.9	86.9	87.9	88.9	89.9	90.9	91.9	92.9	93.9	94.8	95.8	96.8	97.8	98.8	99.8	100.8	101.8
29.5..	85.6	86.6	87.6	88.6	89.6	90.6	91.6	92.6	93.6	94.5	95.5	96.5	97.5	98.5	99.5	100.5	101.5
29.6..	85.3	86.3	87.3	88.3	89.3	90.3	91.3	92.2	93.2	94.2	95.2	96.2	97.2	98.2	99.1	100.1	101.1
29.7..	85.1	86.1	87.0	88.0	89.0	90.0	91.0	91.9	92.9	93.9	94.9	95.9	96.9	97.9	98.8	99.8	100.8
29.8..	84.8	85.8	86.7	87.7	88.7	89.7	90.6	91.6	92.6	93.6	94.5	95.5	96.5	97.5	98.5	99.4	100.4
29.9..	84.5	85.5	86.4	87.4	88.4	89.4	90.3	91.3	92.3	93.3	94.2	95.2	96.2	97.2	98.2	99.1	100.1
30.0..	84.2	85.2	86.1	87.1	88.1	89.1	90.0	91.0	92.0	92.9	93.9	94.9	95.9	96.8	97.8	98.8	99.7

Mr. Whinery.

The author's remarks on the importance of care and deliberation in working out the best possible final location are pertinent. It may be safely asserted that there are in this country a surprisingly large number of railroads located so badly that, were it now possible, a competent engineer could afford to re-locate, at his own expense, the whole line, taking for his compensation a small percentage of what he could save in cost of construction and operation. But while the engineer is not infrequently to blame for faulty location, it is generally attributable to undue pressure upon him to hasten the work and to avoid expense. Very few employers, even among the abler and better informed class of railroad projectors, appreciate the great economy and importance of careful and conscientious location, or have any adequate idea of the time and cost it involves.

As a result, very few locating engineers can look back with satisfaction on a good deal of the work which they felt compelled, under pressure of time and expense, to do less carefully than their judgment dictated.

Vol. XXXI. FEBRUARY, 1905. No. 2.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
INSTITUTED 1852.

PAPERS AND DISCUSSIONS.

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PROBABLE WIND PRESSURE INVOLVED IN THE WRECK OF THE HIGH BRIDGE OVER THE MISSISSIPPI RIVER, ON SMITH AVENUE, ST. PAUL, MINN., AUGUST 20TH, 1904.

Discussion.*

By Messrs. L. J. Le Conte, Charles L. Strobel and E. P. Goodrich.

Mr. Le Conte. **L. J. Le Conte, M. Am. Soc. C. E.** (by letter).—The facts relating to the failure of this viaduct to withstand wind pressures are extremely interesting, and such cases are always instructive. It is hardly to be expected that, at this late date, any defective detail will be definitely discovered and recorded. All that can be done, therefore, is to study probabilities. In the absence of such information, it is but fair to presume that the viaduct was constructed in every way up to the requirements of the specifications of that date, 1886.

Judging from the photographs of the wreck, however, Figs. 1 and 2, Plate XLIII,† and also Fig. 1, Plate XLIV,† the writer is rather inclined to think that in all probability the maximum wind effect was at or near the site of the four-leg tower, at the southeast

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*Continued from December, 1904, *Proceedings*. See November, 1904, *Proceedings* for paper on this subject by C. A. P. Turner, M. Am. Soc. C. E.

† *Proceedings*, Am. Soc. C. E., for November, 1904.

Mr. Le Conte.

end of the 250-ft. span. Everything in the photographs seems to point that way. For example: Fig. 2, Plate XLV,* showing the four pedestals and the wrecked tower, seems to indicate an ordinary case of "tip over," pure and simple, due most probably to lack of proper anchorages to the masonry pedestals. This is indicated by the direction of the upper chord of the 250-ft. fallen span, as it lies in the river. It does not occupy a position which would indicate that the northwest end of the 250-ft. span had given way first. On the contrary, the photographs seem to show that the distance of the upper chord from the original center line of the bridge, at the four-leg tower base, is certainly much greater than the corresponding distance of the upper chord, at the northwest end of the fallen span, from the center line; thus showing, apparently, a decidedly angular position, which prolonged, cuts into the alignment of the bridge proper very perceptibly. It appears to be clear, therefore, that the 250-ft. span was undoubtedly thrown farthest out at the four-leg tower site, and, consequently, this was most probably the locus of the maximum wind effect upon the bridge. It seems to the writer, therefore, more probable that the four-leg tower was torn from its four-pedestal base completely and, toppling over, pulled the other spans after it and the 250-ft. span off its seat on the two-leg bent.

Moreover, it should be remembered that the specifications in vogue in 1886, when the bridge was designed, were probably defective as to anchorage. At least, the writer knows that the everyday practice of that date was the plain, old, ordinary connection of columns to pedestals by an anchor bolt at each of the four corners of the bed-plate. This constituted a miserably weak and ineffective detail for such a high tower. Modern specifications demand that the anchorage shall hold the foot of the column to the pedestal so securely that failure by overturning or rupture at the footing could not occur if the bent were tested to complete destruction, whereas, Fig. 2, Plate XLV,* shows plainly that the four pedestals, after the wreck, were left perfectly clean and free from wreckage, apparently as though there were no anchor bolts in existence.

Just one word more on wind pressures in general: Past records as to wind pressures are extremely vague and unsatisfactory. Of late years, however, instruments have been devised by which the pressures are recorded with commendable accuracy. The results obtained are startling when compared with popular estimates made at the same time. This discrepancy, in a measure, explains itself. The intensity of the wind pressure is generally confined to very narrow limits, and, as a result, two pressure gauges do not give anywhere near the same record; simply because the pressure was not

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* *Proceedings*, Am. Soc. C. E., for November, 1904.

Mr. Le Conte. there to be recorded. Hence, no single observation of pressure is of much value, simply on account of the well-known and great variation in pressures within short distances. What the bridge engineer really wants to obtain, most of all, is a reliable average for a given entire span; and, as might be naturally inferred, within limits, the longer the span the less the average.

The writer does not think that a rational conclusion can possibly be arrived at, except by actual observations on existing bridges. This information is now very badly needed, more particularly when making specifications for long-span bridges.

Mr. Strobel. CHARLES L. STROBEL, M. AM. SOC. C. E. (by letter).—The author assumes a wind acting upward at an angle of 30° to the horizontal and blowing against the underside of the floor of the bridge with a pressure of 30 lb. per sq. ft. in that direction. This floor has a width of 41 ft., and, on this assumption, the exposed area is therefore very considerable. This force he divides into two components, one acting normal to, and the other parallel with, the floor. The force normal to the floor is assumed at 20 lb. (in round figures) per sq. ft. and the horizontal force at 10 lb. per sq. ft. These figures were obtained from Unwin's table for wind pressures on roofs, but the writer thinks that the use made by the author of the latter figure is erroneous. In that table this figure is the horizontal component of the normal pressure, which, there, is a force inclined to the vertical. On this account, it is convenient to make use of the horizontal and vertical components of the normal pressure instead of utilizing the latter, direct.

In this case, however, the normal force is vertical, and is used by the author in full; therefore, a component of this force should not also be used. The horizontal component of the original inclined force of 30 lb. per sq. ft. against the underside of the floor, on the other hand, exerts a pressure upon the bridge only through friction of the air against the floor, and this friction would be only a very small percentage of this force, so small that it is usual to neglect it. The writer thinks that the horizontal force of 10 lb. against the underside of the floor should be eliminated entirely from the author's calculations. Making this correction, and increasing the pressure against the sides of the trusses from 210 lb. (= 30 lb. × 7) per lin. ft., assumed by the author, to 300 lb., the specification requirement, we obtain, for the 250-ft. span, the dead load required for equilibrium

$$= \left\{ 300 \text{ lb.} \times 125 \times \frac{30}{22} \text{ (overturning force)} + 50\,100 \text{ lb. (uplifting force)} \right\} \times \frac{2}{125} = 1\,620 \text{ lb.}$$

Mr. Strobel.

per lin. ft. of bridge. In other words, the 250-ft. span will not be overturned by a horizontal wind pressure of 300 lb. per lin. ft. acting in the plane of the top chords, combined with a normal upward pressure of 20 lb. per sq. ft. against the floor of the bridge, if the dead weight exceeds 1 620 lb. per ft. Even taking the dead weight at only 2 200 lb., as roughly estimated by the author, it is clear that the destruction of the bridge could not have been caused by the overturning of the 250-ft. span, which was the author's conclusion, unless the wind pressures were much greater than he assumes.

Upon inquiry, the writer finds that the wooden floor of the bridge is different now from what it was when the bridge was originally built, sixteen years ago. The upper or wearing floor was 4-in. cedar blocks then; it is 2-in. oak plank now. The dead weight of the 250-ft. span is given at 3 200 lb. per lin. ft. on the original stress sheet, as against 2 200 lb. assumed by the author, which is evidently much too small, even for the present floor.

The specifications, under which the bridge was built, provided for horizontal wind pressures only, and these were 300 lb. per lin. ft. of bridge in the plane of the top chords, and 150 lb. per lin. ft. of bridge in the plane of the bottom chords. These are Cooper's requirements for wind for highway bridges. They were standard then, and are standard to-day. For these wind pressures, anchor bolts are required to resist overturning, neither at the end of the 250-ft. span nor at the foot of the tower. At the end of the 250-ft. span the dead load exceeds the overturning force of the wind by 148 900 lb. for each shoe, and at the foot of the tower, for the bent supporting the 250-ft. span, by 68 300 lb., according to the original stress sheet. Assuming the author's lighter dead weight, these figures would be 86 400 lb. and 5 800 lb., respectively, but his dead load is probably 840 lb. per ft. too small for the present floor. The bridge, therefore, would not have failed under the wind pressures allowed for, even if the anchor bolts were without nuts, the condition in which some of them were found. Although, as shown, under the original dead loads, anchor bolts were not needed to hold down the bridge, they were provided as an extra precaution, and were of liberal size. They were intended primarily to hold the bed plates in position laterally, and were run through the bottom plate of the shoe, but not with the desire of developing the full strength of the bolts in tension. To do this it would have been necessary to increase the thickness of the bottom plates. Still, these anchor bolts were good for a considerable resistance to an uplifting force, and, of course, they should have been kept in proper working order.

This bridge was designed with the same care and attention to details as any modern railroad bridge. Shop plans were submitted for approval, and were carefully gone over by a thoroughly com-

Mr. Strobel. petent, conscientious and painstaking engineer, A. W. Münster, M. Am. Soc. C. E., then Bridge Engineer of the City of St. Paul.

The author's theory, that the bridge failed by the overturning of the end of the 250-ft. span, which rested on the rocker bent, seems improbable from the fact that this would require so large an upward pressure against the wooden floor that the clinched wire nails, with which the floor was fastened to the iron stringers, would be torn off before the bridge could be lifted up.

A much more probable theory would appear to be that the bridge was wrecked by the overturning of the tower at the shore end of the 250-ft. span, the other spans following in natural sequence. At the tower the surplus of dead load to resist overturning was very much less than at the end of the 250-ft. span, as has been shown. Furthermore, beginning at or close by this tower, the shore rises abruptly on the south side of the river. The wind is reported to have blown diagonally against this slope, and therefore would have been deflected upward so as to exert considerable pressure against the underside of the floor. This pressure was probably sufficient to overturn the tower, especially if the anchor bolts were partly without nuts, as reported.*

As to the lessons taught by the failure of the bridge: the first and most obvious one would seem to be that anchor bolts for high bridges or viaducts should be looked after, and nuts replaced if lost or stolen; secondly, that the floor of a high viaduct should not be made lighter in weight without an investigation as to whether the anchorage provided is still sufficient to resist wind, and, if not, to strengthen the anchorage as may be required by the new conditions.

The writer's conclusion, in general, is that our present assumptions for wind pressure did not prove adequate to save this bridge, and that either the intensity of the wind was much greater than the pressures ordinarily allowed for, or that the wind, though not of greater intensity, was deflected upward by the steep slope of the high south shore and thereby given an intensified effect sufficient to cause the failure of the spans near this end, under the unfavorable conditions of a lightened floor and anchor bolts apparently in bad order.

The writer agrees with Mr. Cooper that in future provision should be made for certain upward wind forces, but in any general specifications these forces should be stated definitely, and not left to be deduced from wind pressures acting at a certain angle with the horizontal.

The old method of obtaining the wind pressures, by the parallelogram of forces, is obsolete, as it has been shown by modern experiments that the normal pressures can be deduced from experiment

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* See Mr. R. A. Tanner's account of the failure, showing the position of the wrecked structure, *Engineering News*, December 8th, 1904.

Mr. Strobel.

only. A splendid beginning, in the scientific investigation of wind pressure, has been made by the Committee of the British National Physical Laboratory,* and further experiments are promised, so that we may soon hope to know more about wind pressure than heretofore. Attention is called to the fine opportunities for observation on a large scale afforded by modern bascule bridges, and those in a position to do so are urged to make and publish records of the power required to operate these bridges in high winds, measuring at the same time the direction and velocity of the wind. Such observations would be very valuable.

Mr. Goodrich.

E. P. Goodrich, Jun. Am. Soc. C. E. (by letter).—The subject of wind pressures has interested the writer for several years past, during which period he has been making continued observations and investigations, both mechanical and analytical. He also had some very vivid experiences in the cyclone which struck Ypsilanti, Mich., on the evening of April 12th, 1893.

While the damage done to the St. Paul bridge is well described by Mr. Turner, his description of the storm which wrecked it is rather meager. From technical publications, from the United States Weather Bureau, and by letter from Mr. Turner, personally, the writer has gathered a few additional facts. The storm was cyclonic; came against the bridge almost normally; had a width of path of destructive effect of approximately 250 ft.; developed wind velocities of 110 and 125 miles per hour, at the Weather Bureau observatories in Minneapolis and St. Paul, respectively; and caused a variation in barometric pressure from 28.40 to 28.25 and then to 28.80 in.

In his observations of the storm at Ypsilanti, the writer noted many facts which were similarly noted by Mr. Turner, as published at the time of the St. Paul storm.† It is the writer's opinion that, in such storms, the most damage is done by the rush of air toward and up the vortex which forms the storm center. In several instances in Ypsilanti the brick walls of well built houses were burst outward on two sides while the edge of the track of the vortex seemed to be several feet distant. Mr. Turner‡ describes a roof which was burst outward on the leeward side of the gable while the windward side remained in position. Many such published and personally made observations have convinced the writer that there is apt to be as much suction on the lee side of thin structures, like walls, bridge floors, etc., and on the lee side of many gable roofs, as pressure upon the windward side. He has always made it a practice to take due account of these facts when designing the supports

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* See Stanton on "The Resistance of Plane Surfaces in a Uniform Current of Air," *Minutes of Proceedings*, Inst. C. E., Vol. CLVI (June, 1904).

† *Engineering News*, September 1, 1904, pp. 192–196.

‡ *Ibid. Engineering News.*

Mr. Goodrich. of roof trusses, etc. It seems as if the actual cause of the accident described by Mr. Turner was a failure to appreciate and provide for this condition.

The actual pressures due to non-cyclonic winds are of equal importance to the engineer, and should be as carefully studied. Mr. Cooper has proposed a most sensible specification, in the writer's opinion, in requiring designs to withstand pressures of decreasing amount, as greater areas are considered. The observations made by the writer, while not yet complete enough for publication, and the analytical investigations which followed the securing of the first consistent data, seem to point to a wind pressure which varies inversely as the logarithm of the least dimension of the area in question. The law of the variation of the pressure with the square of the velocity also holds for any given area through the usual range of variation, but many formulas used for the reduction of anemometer observations are faulty, and are misleading in their results.

In view of all available data with which the writer is acquainted, he considers Mr. Cooper's specification right in theory and amply conservative in practice, provided a stipulation is added that equal suction effects are to be provided against on the lee side of sloping roofs, and that bridge floors, members, etc., are to be fastened so as to withstand the specified pressures from below as well as from all other directions. To be sure, the dead weights of most parts of structures are more than sufficient to overcome such forces in most cases; it is to be noted, however, that a sudden variation in atmospheric pressure of 1 in. of the barometric column (to which we are all accustomed when extended over a long period), will exert a stress of approximately 70 lb. per sq. ft. Some idea of the actual pressures resisted by high buildings can be easily secured by a few observations with any good aneroid barometer on the leeward and then on the windward side of such a structure. The sudden variation in pressure during the St. Paul storm would produce, under proper conditions, a pressure of 10½ lb. per sq. ft., aside from the effect of any impact due to wind velocity.

The theoretical investigation of the stresses due to a cyclonic vortex are most interesting, and explain many curious phenomena. The whole subject is one in which data are so scarce that all information, such as that contained in this paper, is of great value.

Vol. XXXI. FEBRUARY, 1905. No. 2.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PAPERS AND DISCUSSIONS.

This Society is not responsible, as a body, for the facts and opinions advanced in any of its publications.

MAXIMUM RATES OF RAINFALL AT BOSTON.

Discussion.*

By Kenneth Allen, M. Am. Soc. C. E.

Mr. Allen. Kenneth Allen, M. Am. Soc. C. E. (By letter.)—Previous to 1880 there was very little reliable information concerning the intensity of rainfall during short periods. Since then, by the introduction of self-registering gauges, many data, particularly valuable to the engineer in the design of municipal work, have been secured, and the marked similarity between the several curves shown by the author, with the exception of Talbot's Maximum, is a measure of the reliability of the several series of records upon which they were based.

The writer has kept rough memoranda of excessive rainfalls for a good many years, and, in looking them over, finds the following (not already mentioned by the author) that lie above the Maximum Chestnut Hill curve:

Of the thirty-one rates of precipitation noted, eighteen of which are for the Eastern States, seventeen exceed the rates for corresponding intervals shown by Professor Talbot's Maximum curve, and, of the latter, but six are for periods of less than 2 hours. Rates for shorter periods almost invariably fall within the Maximum Chestnut Hill curve.

Although more data are desirable, in order to form conclusions, the writer, from the fact that his complete list includes a larger pro-

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*This discussion (of the paper by Charles W. Sherman, M. Am. Soc. C. E., printed in *Proceedings* for December, 1904), is printed in *Proceedings* in order that the views expressed may be brought before all members of the Society for further discussion.

Communications on this subject received prior to March 25th, 1905, will be published subsequently.

Mr. Allen.

portion of observations for short periods, is inclined to think that, for periods of 2 hours or more, the curves shown for maximum rates of precipitation are relatively low; and that a curve, like Talbot's Maximum, that barely excludes a small number of phenomenal downpours for short periods, might well be extended so as to include a rate of ½ in. for 24-hour periods.

TABLE 2.—RATES OF PRECIPITATION.

Rates of Precipitation Lying Between the Maximum Chestnut Hill and Talbot Curves.

Locality.	Date.		Rate of Precipitation, in inches.	Duration.	
				Hours.	Minutes.
Kansas City, Mo	June	17, 1895.	5.25	0	20
Kansas City, Mo	May	12, 1886.	6.00	0	25
Indianapolis, Ind.	July	.., 1876.	5.76	0	25
Washington, D. C	July	.., 1881.	3.78	0	37
Chelsea, Vt.	July	6, 1897.	3.68	1	00
Newark, N. J	Aug.	24, 1897.	2.95	1	00
St. Louis, Mo	July	8, 1898.	2.48	1	03
Baltimore, Md	July	11, 1884.	2.18	1	43
Norfolk, Va	Aug.	14, 1898.	2.54	1	53
Jacksonville, Fla	June	.., 1903.	1.68	2	30
Atlantic City. N. J	June	22, 1903.	1.94	2	30
South Canistea, N. Y	May	31, June 1, 1889.	1.50	3	00
Reading, Pa	Oct.	12, 1897.	1.36	3	00
Atlantic City, N. J	June	22, 1903.	1.01	4	30

Rates of Precipitation Lying Above the Maximum Talbot Curve.

Locality.	Date.		Rate of Precipitation, in inches.	Duration.	
				Hours.	Minutes.
Galveston, Tex	June	.., 1871.	16.9	0	14
Embarras, Wis	May	.., 1881.	9.2	0	15
Sandusky, Ohio	July	.., 1879.	9.0	0	15
Brattleboro, Vt	July	7, 1897.	6.78	0	20
Biscayne, Fla	March	.., 1874.	8.2	0	30
Newton, Pa	Aug.	.., 1843.	8.25	0	40
Brandywine, Pa	Aug.	5, 1843,	5.00	2	00
Newark, N. J	Aug.	24, 1897.	2.58	2	20
Concordia, Pa	Aug.	5, 1843.	5.33	3	00
Newtown, Del	Aug.	5, 1843.	4.33	3	00
3 miles above Canistea, N. Y	May	31, June 1, 1889.	2.00	3	00
Wellsboro, N. Y	May	31, June 1, 1889.	0.75	10	00
Cuyamoca Dam, San Diego Co., Cal	Feb.	.., 1891.	0.70	10	00
Meriden, Miss	Apr.	15, 16, 1900.	0.77	12	00
Jewel, Md	July	26, 7, 1897.	0.83	18	00
Mayport, Fla	Sept.	29, 1882.	0.57	24	00
Cuyamoca Dam, San Diego Co., Cal	Feb.	.., 1891.	0.43	54	00

Although it is not known whether or not the gauges were self-registering, it will be noted that there are three instances in Table 2 —at Newark, N. J., Chelsea, Vt., and St. Louis, Mo.—in which a rate of more than 2 in. was maintained for an hour.

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THE RECLAMATION OF RIVER DELTAS AND SALT MARSHES.

Discussion.*

By L. J. Le Conte, M. Am. Soc. C. E.

Mr. Le Conte.

L. J. Le Conte, M. Am. Soc. C. E. (by letter).—This subject has always interested the writer, who has had considerable experience in work of this class. Of all enterprises, this is, without exception, the most alluring and the most fascinating. If a favorable location is selected, if the works are faithfully executed in a good workmanlike manner, if properly administered, and if judgment is exercised in keeping up all necessary repairs; then most wholesome and satisfactory results will follow, but not otherwise. The supervision of such works demands a high order of intelligence—too high for the average citizen—and, as a general rule, such enterprises too often fail from sheer neglect.

The writer is pleased with the way the author has handled the subject. The engineer in charge should always consider the worst case that could possibly happen, because the worst always happens. He mentions a Gulf storm raising the level of the water 7.0 ft. above mean low water, but does not state how long the water was maintained at that level; nor whether similar storms are prevalent during the cropping season. It is true that in the case of rice culture the flooding of the tract by heavy rainfall, while the gates are

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* Continued from January, 1905, *Proceedings*. See November, 1904, *Proceedings* for paper on this subject by J. Francis Le Baron, M. Am. Soc. C. E.

Mr. Le Conte. closed by outside storm waters for two or three days, would do no serious damage, but, with other crops, it might be quite embarrassing, to say the least, and, if much protracted, might cause serious loss.

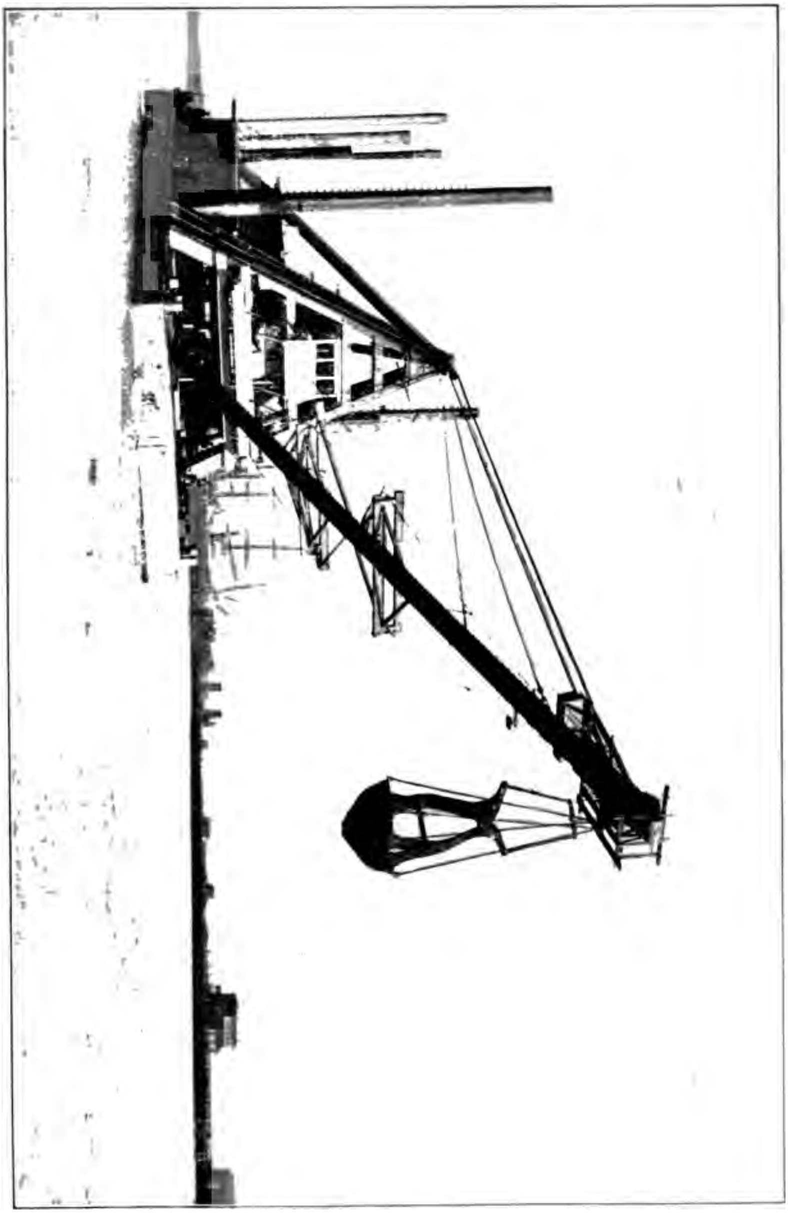
In laying out the lines of canals and ditches in the typical 4 by 8-mile tract, the writer was interested to note the apparent change from the old and well-established plan of such works, as generally laid out. According to the author's plan, the water surface in the canals and ditches, collectively, will amount to one-sixtieth of the total area of the tract; whereas, under the old general plan of canals and ditches, the water surface in all the canals and ditches combined would amount to one-seventy-fifth of the total area of the tract. This may be somewhat hypercritical, but, nevertheless, it is worthy of mention. It may be true that irrigation facilities may call for the change from the customary plan, and probably they do, to a certain extent.

The writer was surprised to note the small quantity of water needed for rice culture—29 and 37 in., including rainfall—and that the time extends only over from 64 to 70 days. This fact is of paramount importance, and puts new life into the business.

The writer has never seen the Menge pump, but can well imagine its good features. From long experience, however, he is inclined to prefer the plain centrifugal pump, as being best adapted to such work. The pumps of the best type are those having runners with a face width equal to the radius, so that the free openings in the runner have a width equal to the diameter of the suction pipe. Friction is very much reduced by this design, and, in the long run, it makes a marked difference in efficiency. The greatest monthly quantity to be pumped, mentioned by the author, seems to be well considered. It agrees very well with the old English and Dutch rules of ¼ to ⅜ in. of rainfall per 24 hours.

The cost of excavating—5 cents per cu. yd.—is considerably greater than the actual cost of doing such work in California. For small jobs, under contract, this figure may be fair enough, but, for a job of considerable size, it would pay the land proprietor to build his own machine and do the work himself, at a cost not exceeding 2 cents per cu. yd. in place. The machine best adapted to do this work economically is the clam-shell dredge, with a 150-ft. boom, capable of making long reaches. Such a machine would not cost more than $40 000, and would only require a captain, a cook and a crew of four men on each shift. The daily expenses would not exceed $60, and the average output would be at least 3 000 cu. yd., making the actual cost not greater than 2 cents per cu. yd., as above mentioned. This dredge is shown in Plate XXI. It will be noted that the bucket is of a type out of the ordinary, and is the result of

PLATE XXI.
PAPERS, AM. SOC. C. E.
FEBRUARY, 1905.
LE CONTE ON
RECLAMATION OF RIVER DELTAS.



Dredge with Long Boom and "Clam-Shell" of Special Form.

Mr. Le Conte. long experience in this particular class of work. The efficiency and ease with which it can be handled cannot be praised too highly. The lever arms, extending back from the bucket on each side, answer two purposes, both of which are of inestimable value; namely, the whole weight of the bucket and leverage is available for closing, and, when opening the bucket, the weight of the arms exactly balances the weight of the shells; so that, figuratively speaking, a school boy could manipulate the empty bucket. The capacity of these buckets ranges from 3 to 10 cu. yd. The writer is inclined to think that for all practical purposes the 5-cu. yd. bucket is the handiest size.

MEMOIRS OF DECEASED MEMBERS.

NOTE.—Memoirs will be reproduced in the Volumes of *Transactions*. Any information which will amplify the records as here printed, or correct any errors, should be forwarded to the Secretary prior to the final publication.

GEORGE SHATTUCK MORISON, Past-President, Am. Soc. C. E.*

DIED JULY 1ST, 1903.

George Shattuck Morison was born in New Bedford, Massachusetts, December 19th, 1842.

His father was a Unitarian minister, of Scotch-Irish stock, and settled originally at Peterboro, New Hampshire, where in later years Mr. Morison made his home, though most of his boyhood was passed at Milton, near Boston, where he early developed a faculty for surveying and architecture. He was prepared for college at the Phillips Exeter Academy, and was graduated from Harvard University, with the degree of Bachelor of Arts, in 1863. When at Harvard he was considered the best scholar in mathematics in his class.

Notwithstanding his mathematical inclination, he studied law and was graduated from the Harvard Law School in 1866 with the degree of Bachelor of Laws. He was admitted to the New York Bar the same year. He associated himself with the firm of Evarts, Southmayd and Choate, but, a year later, began his work as a civil engineer, for which he had no special education or training.

As an engineer, he rapidly won distinction and power, and long before his death he had become eminent. He was elected a member of the American Society of Civil Engineers on January 6th, 1875, and in 1895 became its President, the highest strictly professional honor which an engineer can reach in America. He was a Member and Telford Medallist of the Institution of Civil Engineers. He was a Member of the Western Society of Civil Engineers, of which he was for three years a Trustee; a Member of the American Society of Mechanical Engineers; of the American Institute of Mining Engineers; and of the Mexican Society of Engineers and Architects; an Associate Fellow of the American Academy of Arts and Sciences; a Fellow of the American Academy for the Advancement of Science, and a member of various other learned and scientific societies.

He had served on various important engineering boards and commissions, under appointments from the General Government and from State and municipal governments, which will be mentioned later. The most important of these was the Isthmian Canal Commission of 1899 and 1903, the labors of which practically determined the route on which that canal will be built. In brief, his reputation as an engineer and engineering counsellor was international.

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*Memoir prepared by E. Gerber, H. G. Prout and C. C. Schneider, Members, Am. Soc. C. E.

That a man of academic education, and bred for the law, should have risen so fast and gone so far as an engineer is an extraordinary and interesting fact. Briefly, he had the sagacity to discover very early in his life that the practice of law was not congenial to his tastes and abilities, and that engineering was. The inexactness of the laws of man could never satisfy him, while the possible exactness of engineering design and construction satisfied his reason; and the possible control of the forces of Nature appealed to his imagination. He was born an engineer, he was not born a lawyer, and he had the courage to change his profession at the outset of his career. The lesson of this interesting life may be suggested by a very brief sketch of his work, and by a few words about his mind and character.

He began his engineering work in October, 1867, on the bridge over the Missouri River at Kansas City, which was being built by Octave Chanute, Past-President, Am. Soc. C. E., and displayed such ability that he was selected to assist in preparing for publication an account of the construction of the Kansas City Bridge, which had become noted for its novelty and difficulties.

From January, 1870, to June, 1871, Mr. Morison was engaged in making examinations of the character and resources of the country through which it was proposed to extend the "Joy roads." In June, 1871, he was called to Detroit to take charge of the Detroit, Eel River and Illinois Railroad, as Chief Engineer. He remained there until April, 1873. By that time, Mr. Chanute having become Chief Engineer of the Erie Railroad, Mr. Morison rejoined him as Resident Engineer of the Eastern Division. The Erie Railroad at that time was chiefly equipped with wooden bridges; the few which were of iron being proportioned for much lighter loadings than those of the new locomotives which it was intended to place upon the line, and Mr. Morison had an ample field for his tastes and talents in reconstructing and strengthening the bridges. He soon became the Principal Assistant Engineer, and when the celebrated Portage Bridge burned down, in 1875, he designed and built the iron structure, which took its place, in six weeks from the date of the conflagration.

He resigned from the Erie Railroad in November, 1875, to become consulting expert on railway properties for Baring Brothers and Company, and was connected with them for ten years. He had shown such individuality that his friends thought that his greatest success would be as a railroad director and manager, and he served as director (representing the Barings) for ten years on the Eastern

Railroad of Massachusetts, four years on the St. Louis, Iron Mountain and Southern Railway, eight years on the Maine Central Railroad, and eight years on the Ohio and Mississippi Railroad, the latter directorship extending to 1892.

From 1875 to 1880 he was a member of the firm of Morison, Field and Company, bridge contractors, from which he retired in order to give all his attention to professional engineering. He at once took a prominent position among consulting engineers by beginning the construction, in rapid succession, of that long list of bridges, over the Missouri and Mississippi and other important rivers, which have made his name so famous.

To bridge the Missouri River in 1880 was still a great undertaking, and had few precedents. His first great bridge was that at Plattsmouth, over the Missouri, and was completed in 1880. It is one of the early bridges in which steel was used to a considerable extent, the two 400-ft. spans being a little more than half steel. The description given by Mr. Morison, in his monograph on the Plattsmouth Bridge, as to how this steel was made, is a bit of interesting history of the early development of the manufacture of structural steel.

Before the Plattsmouth Bridge was opened for traffic, Mr. Morison had let the contracts for the construction of another bridge over the Missouri, at Bismarck, North Dakota. This was completed in October, 1882.

The pneumatic foundations in these two bridges had been sunk under contracts by people more or less familiar with such work. When, however, the bridge at Blair, also over the Missouri, was begun in 1882, Mr. Morison decided to do the pneumatic work himself by day work under experienced foremen, as thereby he could control the work better, use such safety appliances as were not likely to be used by the contractors, and he hoped to achieve some considerable economy. The work at Blair proved so successful that he adopted this plan at nearly all subsequent bridges where pneumatic foundations were required. These came in such succession that he was able to transfer the pneumatic plant from one to the other, and, eventually, a very fine pneumatic plant was developed at a comparatively small cost to any one bridge. The Blair Bridge was opened for traffic in 1883, but the problem there was by no means solved. All Missouri River bridges require more or less shore protection, but at none was the channel so fickle as at Blair, and for several years great sums of money were expended under Mr. Morison's direction for controlling the river, with ultimate complete success.

The old bridge at Omaha being overcrowded with business, and rather light, Mr. Morison was called upon to rebuild it as a double-track structure. The new bridge is essentially new throughout, a few of the old piers only being used for supporting the approach spans. This bridge was practically completed in June, 1888, though it was not used as a double-track structure until October of that year. Before beginning the Omaha Bridge, Mr. Morison had made investigations for and actually begun work on another Missouri River bridge at Rulo, Nebraska. Work on this, however, was suspended for a time, and the bridge was not opened for traffic until September, 1887.

While these bridges were building, Mr. Morison constructed the following bridges on the Pacific Slope: over the Snake River at Ainsworth, Washington, in 1883; and over Clark's Fork of the Columbia, near Belknap, Montana, in 1884.

Up to this time the superstructure of Mr. Morison's great bridges had been made partly of iron and partly of steel, the floor, intermediate posts and laterals being of iron, the remainder of steel. In his next Missouri River bridge, completed in November, 1888, at Sioux City, iron was used only in members requiring welding; the remainder of the superstructure was of steel, either open-hearth or Bessemer. All Mr. Morison's subsequent bridges of large size were built practically entirely of steel.

In 1887 he formed a partnership with E. L. Corthell, M. Am. Soc. C. E., under the firm name of Morison and Corthell. This partnership continued from May 1st, 1887, to May 1st, 1889. The Sioux City and Nebraska City Bridges, across the Missouri; the Cairo Bridge, across the Ohio; the Jacksonville Bridge, across the St. John's, in Florida; the bridge over the Willamette, at Portland, Oregon; the bridge over the Snake River, at Riparia, Washington; and the Bismarck Water-Works were built, and the plans were prepared for the Merchants' Bridge, over the Mississippi, at St. Louis, under their joint direction. The Cairo Bridge was at that time the longest metal bridge in the world, the metal work being exactly 2 miles long.

Before the Cairo Bridge was completed, Mr. Morison began the great bridge at Memphis, Tennessee. It is his greatest bridge work, is the nearest bridge to the mouth of the Mississippi, when completed had the longest truss span in the United States, and was practically second only to the great structure over the Firth of Forth, although its longest span was a few feet shorter than a span in the Lansdowne Bridge, in India. The pneumatic foundations of the Memphis Bridge were really its controlling features, as they were in unusually deep water (about 40 ft.), and were sunk to the extraordinary depth of 108 ft. below water.

The superstructure presented many novel problems, not the least of which was the character of the material of which it was composed. On a structure of such importance, it was worth while to exercise special care in making the steel, and many conferences were held with the steel manufacturers, and a specification resulted which permitted the use of open-hearth or Bessemer steel. After several hundred tons of the latter had been rolled and it had been found extremely difficult to meet the requirements, the use of Bessemer steel was abandoned, with the advice and consent of the manufacturers; that already rolled was sold for other uses, and open-hearth steel, either acid or basic, was used exclusively. Basic steel was then in its infancy, and there was much prejudice against it. The specifications finally developed on the Memphis Bridge have been essentially the basis of all modern bridge specifications throughout the United States. The Memphis Bridge was successfully completed and opened for traffic with great ceremony on May 12th, 1892.

While the Memphis Bridge was being built, Mr. Morison built a bridge over the Mississippi at Winona, Minnesota (1891), and, at Burlington, Iowa, he replaced the original single-track bridge by a double-track structure (1891). These were followed by a bridge over the Missouri at Leavenworth, Kansas, one over the same river at Bellefontaine Bluffs, Missouri (1892-93), and one over the Mississippi at Alton, Illinois (1892-93). He rebuilt the bridge across the Missouri at Atchison, Missouri (1898). This completes the list of his great bridges, of which ten crossed the Missouri, five the Mississippi, and one the Ohio. In addition to these large bridges, he built many smaller bridge and viaduct structures in every part of the United States. In the early Nineties he made an examination and report on a bridge over the Detroit River, at Detroit, and was again engaged on this problem at the time of his death.

In 1889 he made an exhaustive report on the Atchison, Topeka and Santa Fé Railway, and in the next few years reported on several other railroad projects of lesser magnitude.

He competed with others in prize designs for two bridges near Washington, and was awarded a prize in each case.

Mr. Morison served on the following Engineering Boards: The Board of Engineers upon the New York and New Jersey Bridge (1894); the Board to locate a deep-water harbor in Southern California (1897); a Board to report on the betterment of the water front of New York City (1895-97); a Board to advise the State Engineer and Surveyor of the State of New York in regard to the plans and estimates for the so-called Barge Canal (1900-01); the Isthmian Canal Commission (1899-1903); a Commission of engineers to report on the plans of the Manhattan Bridge across the East River (1903). He was Chairman of this Commission, and signed its report on June 29th, 1903, only two days before his death, and this was probably the last document signed by him.

Mr. Morison's part in the studies and the findings of the Isthmian Canal Commission must necessarily remain largely unknown to everyone but the members of the Commission; but enough is known to justify the statement that the nation and the world owes him a good deal. When he entered upon his work with the Commission he had not allowed himself to reach an opinion as to the best route for the canal. He threw himself into the study of the situation with the energy, the determination to know the truth and all the truth, and with the power of investigation and analysis which characterized all his work. He went to Paris and ransacked the archives of the Panama Canal Company; he exhausted the sources of actual information in America, and he went (with other members of the Commission) to Nicaragua and the Isthmus, and examined the ground. There were those who said that he sought the glory of identifying his name with some route other than the two which had come to be accepted as the only practicable ones. This would not have been an ignoble ambition; but his passion for thoroughness is a sufficient explanation of his reluctance to make up his mind. When he decided in favor of the Panama Route he had canvassed the matter so completely that no doubt remained, and he could speak with the conviction and power of knowledge. Apart from his work with the Commission, he delivered a number of addresses before general audiences, which had much weight in making the choice of the Panama Route acceptable, or even possible.

Such is briefly his more important work. It is not necessary to state that such work required a master mind, and when it is considered that Mr. Morison had no special technical training in engineering, but entered the field when he was nearly 25 years of age, it is indeed marvelous. Nature endowed him with a strong intellect and a strong will, and he made the most of them. The whole grand success may be summed up in the word "work." He had no influential friends to help him, whom he did not make himself by his indomitable energy and proven ability. He studied his work carefully and thoroughly, and the minutest detail was not too small to be worked out with the greatest consideration before it was executed. One of his rules was, that if he had five minutes in which to do a thing, he would take three, if necessary, to think it out, and do it in the other two.

In his work he was original, and not merely an imitator or developer of existing ideas. He sought to make the best possible solution of a problem, and not necessarily a solution which had been shown to be a success under similar circumstances. He sought and had a reason for everything, and had the courage to act according to his reason. He did not, however, carry his originality to extremes. Every previous example bearing on a case was carefully studied, and if he found that some existing idea suited his purpose better than any other, he did not hesitate to make use of it and properly gave credit where it was due.

Nor did he fail to consider the commercial practicability of his designs. His work was no doubt of the very highest order of his time, but he did not make it of such extreme character that it could not be practically attained. It was always a little better than had been done before, but never out of reach, and thus he led in the development of bridge building, the better standards of to-day being about up to his requirements of a decade ago.

While Mr. Morison always studied out and knew every detail of his work himself, he was careful to surround himself with a competent, faithful and conscientious staff. An indefatigable seeker after truth and the best obtainable, himself, he expected his staff to be no less energetic, accurate and conscientious in their work than he, and an indolent or slovenly worker did not remain long in his service.

After leaving Detroit, in 1873, Mr. Morison resided in New York City for fourteen years, then in Chicago until 1896, when he returned to New York. He was a great traveler, his work calling him to all parts of the United States, the Isthmus, and Europe. His business travels were supplemented by a trip around the world, as well as smaller ones to Europe and to our Southern neighbors. He was an accurate and minute observer, and this, together with his studious habits and early education, gave him a wonderful and very extended fund of knowledge, which made him an entertaining conversationalist and a scholarly, concise writer.

Considering Mr. Morison's great intellectual activity, and the wide range of his interests, and considering that his whole life, from childhood to his death, was surrounded by an atmosphere of scholarship and letters, the printed record that he has left behind him seems surprisingly small. But the practicing engineer seldom has time to write much for publication. Mr. Morison wrote and published some admirable monographs describing the most important of his bridges. He contributed valuable papers and discussions to the published Transactions of the Engineering Societies to which he belonged, and he delivered numerous lectures and addresses before college classes, learned societies and various professional bodies. Some of these latter have been more or less completely preserved in print, and doubtless most of them exist in manuscript, for Mr. Morison was a methodical man. If his literary work, both that which was strictly professional and that which was semi-popular, can be collected and made available, a material service will be done for his profession. But Mr. Morison left behind him one literary work which is worth particular mention, and that is the little volume entitled "The New Epoch as Developed by the Manufacture of Power." This is a re-writing and expansion of an address, made as President of the American Society of Civil Engineers, an oration delivered before the Society of Phi Beta Kappa at Harvard University, a commencement address at the Rensselaer Polytechnic Institute, and an article printed in the *North American Review*. The book which resulted is highly characteristic of the man. It shows the depth and originality of his thought; it reveals his capacity for high conceptions and powerful generalizations, and expresses his constitutional aversion to many words. In 134 small pages, which may be read in an hour, he has compressed the fruit of years of reading and talking and meditation. The fundamental idea which runs through this little book is that mankind is now entering on a new ethnical period. Mr. Morison sees no reason to accept the idea that with the dawn of civilization the ethnical periods closed, but, on the contrary, he believes that when man learned to manufacture power he entered on a new epoch. This bold and inspiring thought he develops in considering various forms of social organization and activity.

He was for fifteen years a Trustee of the Phillips Exeter Academy, and five years President of the Board, resigning as such in June, 1903. To testify to his belief, as a man of science, in the value of classical study, he began the endowment there of the Morison Professorship of Latin.

He planned and directed, as Chairman of the Building Committee, the construction of Soule Hall—a dormitory—and planned the interior arrangement of Peabody Hall—a second dormitory. A third—Hoyt Hall—was designed and built entirely by Mr. Morison. He shared equally with Professor Wentworth the cost of this building, the amount of money he put into it being considered a part of the endowment of the Morison Professorship of Latin. These three are the most serviceable buildings of the Academy. Mr. Morison was also a member of the Building Committee in charge of the construction of the beautiful Alumni Hall, recently completed. It was designed under his direction by Mr. Casey, an architect, of New York.

Mr. Morison was a member of the Finance Committee throughout the greater part of his trusteeship of fifteen years, and its Chairman many years. Many of the funds were re-invested under his direction, and the Academy received the benefit of his services in many ways not commonly known. He left his mark on every side of the Academy life. He loved the school, and gave much of his thought to its betterment. The Academy had the benefit of his ability, not only in its buildings, but in its funds and every part of its life which needed his aid and encouragement.

Mr. Morison's professional position is secure in the work which he did; his activity in other fields is indicated by the brief record of his service to Phillips Exeter Academy; but the commanding place which he took among the men of his generation is only partly explained by the mere list of his works, long as it is. To understand his position, we must know something of his personal qualities.

He had a powerful intelligence, which would have distinguished him in any calling, and added to that he had in large measure those special gifts which make a man an engineer in spite of accidents of education. He had contrivance; he had a quick and clear perception of cause and effect in material phenomena; he had a feeling for the laws and forces of Nature. So it was not extraordinary that he should have turned from the law to engineering when he was 25 years of age, or that he should have succeeded greatly as an engineer without what is commonly recognized as an engineering education. These special gifts were evident in his childhood, as were the quick and accurate observation and the strong memory by which the born engineer collects and stores the knowledge which makes many of his acts in after life seem to be what we call intuitive. With a strong mind, Mr. Morison had also a strong will. He followed his purposes, great and small, with a persistence and determination which made him hard to work with, but which secured his ends.

Beneath these attributes, which were evident, were others which were not evident to those who knew him but superficially. With all his strength and self-reliance he was a very modest man. In matters where experience had not taught him that he was strong, he was apt to distrust his own judgment. That is, self-reliance with him was largely a product of reason. He was also a diffident man, and had in great measure that reticence about his own affairs which is characteristic of his race and of the region where he was born and bred. These characteristics should be kept in mind by those of his contemporaries who did not know him closely and who try to sum him up as he appeared to them. Finally, in Mr. Morison's attitude toward his fellow man, he belonged to that school of thought of which Herbert Spencer was the most conspicuous representative in modern times. As a matter of principle, and for the ultimate good of society, he would have made every man help himself to the utmost of his power. And yet he did help many with his counsel and his money when he had satisfied himself that they were worthy.

Although Mr. Morison was in his sixty-first year when he died, he was still growing intellectually, and as he was a man of great physical strength and of frugal and abstemious life, and of undiminished energy and abundant means, we can but feel that had he been spared he would have accomplished some work greater than any which he had yet done.

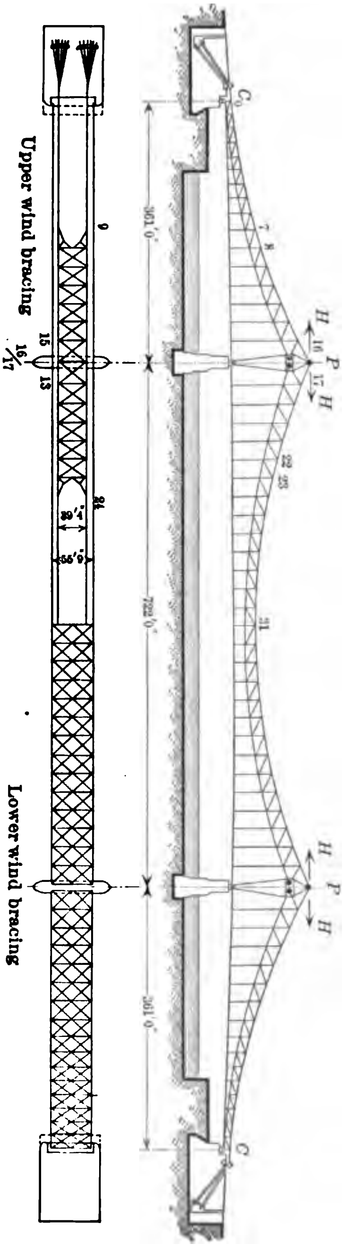

FIG. 9.

This figure was omitted from Mr. Erlinghagen's discussion on Mr. Lindenthal's paper, see page 189.

PROCEEDINGS

OF THE

AMERICAN SOCIETY

OF

CIVIL ENGINEERS.

(INSTITUTED 1852.)

VOL. XXXI. No. 3.

MARCH, 1905.

Edited by the Secretary, under the direction of the Committee on Publications.

Reprints from this publication, which is copyrighted, may be made on condition that the full title of Paper, name of Author, page reference, and date of presentation to the Society, are given.

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NEW YORK 1905.

Entered according to Act of Congress, by the AMERICAN SOCIETY OF CIVIL ENGINEERS in the office of the Librarian of Congress, at Washington.

American Society of Civil Engineers.

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S. L. F. DEYO.

Term expires January, 1907:
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◆

The House of the Society is open from 9 A.M. to 10 P.M. every day, except Sundays, Fourth of July, Thanksgiving Day and Christmas Day.

HOUSE OF THE SOCIETY—220 WEST FIFTY-SEVENTH STREET, NEW YORK.

TELEPHONE NUMBER, - - - 583 Columbus.
CABLE ADDRESS, - - - "Ceas, New York."

Vol. XXXI. MARCH, 1905. No. 3.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PROCEEDINGS.

This Society is not responsible, as a body, for the facts and opinions advanced in any of its publications.

SOCIETY AFFAIRS.

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MINUTES OF MEETINGS.

OF THE SOCIETY.

March 1st, 1905.—The meeting was called to order at 8.35 P. M.; President Schneider in the chair; Charles Warren Hunt, Secretary, and present, also, 128 members and 24 guests.

The minutes of the Annual Meeting, January 18th, and of the meetings of February 1st and 15th, 1905, were approved as printed in the *Proceedings* for February, 1905.

The paper entitled "Technical Methods of River Improvement, as Developed on the Missouri River, by the General Government, from 1876 to 1903," by S. Waters Fox, M. Am. Soc. C. E., was read by title, and the Secretary presented written communications on the paper from Messrs. Samuel H. Yonge and H. M. Chittenden.

Ballots for membership were canvassed, and the following candidates elected:

As Members.

Hiram Bertrand Andrews, Boston, Mass.
Bion Joseph Arnold, Chicago, Ill.
Henry Jackson Burt, Salt Lake City, Utah.
William Hobbs Chadbourn, Jr., Beaver, Pa.
Charles Robert Foran Coutlee, Ottawa, Ont., Canada.
Frank March Haines, Fort Worth, Tex.
George Fiske Hardy, New York City.
Guy Moulton, Syracuse, N. Y.
William Henry Penfield, San Francisco, Cal.
Cornelius Van Vorst Powers, New York City.
Henry Wilson Rockett, Perth, Western Australia.
Cecil Brunswick Smith, Toronto, Ont., Canada.
Frank Soulé, Berkeley, Cal.
William Franklin Strouse, Washington, D. C.

As Associate Members.

Charles Baker Burdick, Chicago, Ill.
Charles Enzian, Wilkesbarre, Pa.
Arthur Burling Foote, Grass Valley, Cal.
James Wesley Gallagher, London, England.
Lewis Tustler Haney, Brooklyn, N. Y.
Richard Willis How, Brooklyn, N. Y.
Isaac Wendell Hubbard, Philadelphia, Pa.
Thomas Courtney Moorshead, Edwardsville, Ill.
Lewis Jefferson Proctor, San Juan, Porto Rico.
Harry Howard Rankin, Pittsburg, Pa.
George Crosby Saunders, Philadelphia, Pa.
Courtland Elmore Smith, Ossining, N. Y.
Clinton Glencairn Wells, Galveston, Tex.

As Associates.

Thomas Herbert Letson, New York City.
Domingo Anthony Usina, New York City.

The Secretary announced:

The transfer of the following candidates, by the Board of Direction, on February 28th, 1905:

From Associate Member to Member.

Maurice Fritchley Brown, Boston, Mass.
Walter Reuben Marden, Albany, N. Y.
Charles Henry Nichols, New Haven, Conn.

The election of the following candidates, by the Board of Direction:

AS JUNIORS.

On January 3d, 1905.
RAMIRO FRANCISCO ANTONIO FERRADAS, New York City.
On January 31st, 1905.
CLYDE WEBSTER MCCORNACK, Phœnixville, Pa.
On February 28th, 1905.
LESTER BERNSTEIN, Morgantown, W. Va.
HARRY OTTO GARMAN, West Lafayette, Ind.
FRANCIS FIELDING LONGLEY, Watertown, N. Y.
JAMES CALDWELL PARK, Watertown, N. Y.
GEORGE EDWARD PELLISSIER, Holyoke, Mass.
CARL ROBERT WEIDNER, Independence, Kans.

Adjourned.

March 15th, 1905.—The meeting was called to order at 8.30 P. M.; President Schneider in the chair; Charles Warren Hunt, Secretary; and present, also, 105 members and 16 guests.

A paper, entitled "The Compensating Works of the Lake Superior Power Company," by G. F. Stickney, Assoc. M. Am. Soc. C. E., was presented by the author and illustrated with lantern slides.

The Secretary announced the death of Richard Somers Hayes, elected Member September 6th, 1882; died March 2d, 1905.

Adjourned.

OF THE BOARD OF DIRECTION.

(Abstract.)

February 28th, 1905.—President Schneider in the chair; Chas. Warren Hunt, Secretary; and present, also, Messrs. Craven, Knap, Noble, Osgood, Kuichling and Webster.

It was decided to retain the seven geographical districts into which the membership of the Society is divided for the purposes of the Nominating Committee without change for the next year.

Applications were considered, and other routine business transacted.

Three Associate Members were transferred to the grade of Member, and six candidates for Junior were elected.

Adjourned.

ANNOUNCEMENTS.

The House of the Society is open from 9 A. M. to 10 P. M. every day, except Sundays, Fourth of July, Thanksgiving Day and Christmas Day.

MEETINGS.

Wednesday, April 5th, 1905.—8.30 P. M.—A regular business meeting will be held. Ballots for membership will be canvassed, and a paper, entitled "A New Swing Bridge at Copenhagen, Denmark," by H. C. V. Möller, Esq., will be presented for discussion.

This paper is printed in this number of *Proceedings*.

Wednesday, April 19th, 1905.—8.30 P. M.—At this meeting a paper, entitled "The Reconstruction of the Baltimore and Ohio Railroad Bridge over the Ohio River, at Benwood, West Virginia," by J. E. Greiner, M. Am. Soc. C. E., will be presented for discussion.

This paper is printed in this number of *Proceedings*.

ANNUAL CONVENTION.

The Thirty-Seventh Annual Convention will be held in Cleveland, Ohio, June 20th-23d, 1905. The following Committees have been appointed to take charge of the arrangements.

COMMITTEE OF THE BOARD OF DIRECTION:

ALFRED CRAVEN, *Chairman;*

N. P. LEWIS,	CHARLES S. GOWEN,
W. J. WILGUS,	CHAS. WARREN HUNT.

LOCAL COMMITTEE:

A. MORDECAI, *Chairman;*

WM. J. CARTER,	F. C. OSBORN,
HARRY FULLER,	W. P. RICE,
E. A. HANDY,	J. RITCHIE,
A. M. JOHNSTON,	W. H. SEARLES,
M. W. KINGSLEY,	S. T. WELLMAN,
J. FRANCIS LE BARON,	C. H. WRIGHT.

PRIVILEGES OF LOCAL SOCIETIES EXTENDED TO MEMBERS OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS.

The Boston Society of Civil Engineers will welcome any member of the American Society of Civil Engineers at its library and reading room, 517 Tremont Temple, Boston, which is open on week days from 9 A. M. to 5 P. M. Members will also be welcome at the meetings, which are held in the same building, on the evenings of the fourth Wednesday in January, and the third Wednesdays of other months, except July and August.

The rooms of **The St. Louis Engineers' Club** are in the business center of St. Louis, and visiting engineers are cordially invited to use them for mail, telephone service, information, etc.

The courtesies of **The Engineers' Society of Western Pennsylvania** have been extended to members of the American Society of Civil Engineers. The rooms of the Society, 410 Penn Ave., Pittsburg, Pa., are open at all times, and meetings are held as follows, except during July and August. REGULAR SECTION, Third Tuesdays; CHEMICAL SECTION, Thursdays following third Tuesdays; MECHANICAL SECTION, First Tuesdays; STRUCTURAL SECTION, Fourth Tuesdays.

The Western Society of Engineers, Monadnock Block, Chicago, Ill., tenders to members of this Society the use of its rooms and facilities, together with the good offices of its Secretary and of a special committee appointed for that purpose.

The Civil Engineers' Club of Cleveland, Ohio, invites members of this Society to make use of the Club rooms, at any time when in Cleveland. Cards will be furnished on application to the Secretary, Mr. J. C. Beardsley.

The Engineers' Club of Central Pennsylvania has established new quarters at the corner of Second and Walnut Streets, Harrisburg, Pa., and desires to extend the courtesies of the Club to visiting members of the American Society of Civil Engineers.

SEARCHES IN THE LIBRARY.

In January, 1902, the Secretary was authorized to make searches in the Library, upon request, and to charge therefor the actual cost to the Society for the extra work required. Since that time many such searches have been made, and bibliographies and other information on special subjects furnished.

The resulting satisfaction, to the members who have made use of the resources of the Society in this manner, has been expressed frequently, and leaves little doubt that, if it were generally known to the membership that such work would be undertaken, many would avail themselves of it.

The cost is trifling, compared with the value of the time of an

engineer who looks up such matters himself, and the work can be performed quite as well, and much more quickly, by persons familiar with the Library.

Copies of all lists of references are filed, so that in many cases it is only necessary to make a typewritten copy, which reduces the cost of searches to a minimum.

In asking that such work be undertaken, members should specify clearly the subject to be covered, and whether references to general books only are desired, or whether a complete bibliography, involving search through periodical literature, is desired.

INTERNATIONAL ENGINEERING CONGRESS PUBLICATIONS.

The first volume of the Proceedings of the International Engineering Congress is now ready for distribution to all Members elected prior to December 31st, 1904. There will be six volumes in all. Members have been notified that they would receive these volumes (issued as Parts A, B, C, D, E and F of Vol. LIV of *Transactions*) and asked whether they wished them bound in one of the Standard Bindings. A number of Members who have their Volumes bound regularly have not responded, and consequently will receive these volumes in paper covers, unless an order is received at once for their binding. It is urged that all who care to have these volumes bound, and who have not already done so, send in an order for such binding immediately.

The notation of these volumes, as Parts of one of the regular volumes of *Transactions,* was adopted for the convenience of Members, so that when all are received they will be consecutive on the shelf. It was not possible at the time to say how long it would take to collate the discussions and issue these volumes, and it was thought best to issue them as Parts of Vol. LIV.

It is now expected that at least five of these volumes, and possibly all, may be forwarded to Members prior to the date they will receive the regular Volume LIV, and this explanation is given so that the membership may understand that, for them, there will be seven Parts of Vol. LIV, and that the regular Volume whose shelf place should be first, will probably not be received until after these Engineering Congress Publications.

ACCESSIONS TO THE LIBRARY.

From February 8th to March 7th, 1905.

DONATIONS.*

FOWLER'S MECHANICAL ENGINEER'S POCKET BOOK, 1905.

Edited by William H. Fowler. Leatherette, 6 x 4 in., illus., 78 + 498 pp. Manchester, Scientific Publishing Co. 1 shilling, 9 pence.

This edition has a new section on Entropy and its application to Steam-engine practice. Notes have also been compiled on a variety of engineering questions which are now coming into prominence, such as steam turbines, high-speed tool steel, emery grinding, milling, reaming, etc. At the same time, the whole matter has been revised, and where necessary, amended, so as to keep it, as far as possible, abreast with current practice. There is an index of nearly twenty-three pages.

LOCOMOTIVE OPERATION.

A Technical and Practical Analysis. By G. R. Henderson. Cloth, 9 x 6 in., illus., 7 + 528 pp. Chicago, *Railway Age*, 1904. $3.50.

The author states, that the object of this work is a complete and systematic discussion of the theory and practice of locomotive operation, that is, the work or results accomplished by a locomotive in motion, together with the effect upon itself and the track, and the amount of fuel and water needed to perform such work, rather than an exclusive treatise upon the mere manipulation of the machine, though the latter naturally forms a part of the study, in connection with the proper manner of procuring certain results. Inertia is first considered; the Action of Steam is next examined in detail, as to the power of producing rotation and strains in the various members of the mechanism; Resistance follows, and then Slipping and Braking; Steam Capacity; Hauling Capacity; Water and Fuel Consumption. It has been the author's endeavor to discuss, in a technical and practical manner, the various laws of mechanics which govern the subject. Numerous elementary formulæ have been presented and tables and diagrams freely introduced. There is an index of eleven pages.

ELEMENTS OF MECHANICS.

Forty Lessons for Beginners in Engineering. By Mansfield Merriman, M. Am. Soc. C. E. Cloth, 7 x 5 in., 172 pp. New York, John Wiley & Sons; London, Chapman & Hall, Limited, 1905. $1 net.

The preface states, that this elementary volume is an attempt to apply the best methods of applied mechanics to the development of the fundamental principles and methods of rational mechanics. To this end, constant appeals are made to experience, numerous numerical illustrations are given, many queries and problems are stated and a system of units is employed with which nearly every one is acquainted. The author says that to read this volume with interest and profit, only a knowledge of plane geometry, elementary algebra, and plane trigonometry is required. It is intended for manual-training schools, freshman classes in engineering colleges, and for young men in general who have the preparation just indicated. The contents are: Concurrent forces; Parallel forces; Center of gravity; Resistance and work; Simple machines; Gravity and motion; Inertia and rotation. The appendix contains: Answers to problems; Trigonometric functions; and an index of nearly two pages.

LES DÉCHETS INDUSTRIELS.

Récuperation-Utilisation. Par Paul Razous. Paper, 10 x 6 in., illus., 380 pp. Paris, Vve. Ch. Dunod, 1905. 12 francs, 15 centimes.

The author states, that, for the benefit of manufacturers, chemists and agriculturists, he has examined in his new work the use of scraps and wastes common at most factories; besides having an appreciable value as fuel, fodder, etc., their disposal often adds to the healthfulness of the neighborhood. The book first takes up the wastes connected with oiling, wiping and cleaning of machinery; the mode of lighting, etc. Then follows a review of the possible use of wastes obtained in a great variety of factories and the process by which the product is extracted, when the value of the article obtained is greater than the expense of the treatment.

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*Unless otherwise specified, books in this list have been donated by the publishers.

Gifts have also been received from the following:

Am. Gas Light Assoc. 1 bd. vol.
Am. Soc. of Mech. Engrs. 1 bd. vol.
Anthony, Charles, Jr. 2 pam.
Baker, M. N. 2 bd. vol., 28 pam.
Baltimore—Harbor Board. 1 pam.
Brinckerhoff, H. W. 3 pam.
Charles River Basin Comm. 1 pam.
City Record. 3 bd. vol.
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D. L. & W. R. R. Co. 1 pam.
Fuller, G. W. 1 pam.
Great Britain—Patent Office. 9 pam., 3 vol.
Green, B. R. 1 vol.
Haupt, L. M. 1 pam.
Inst. of Gas Engrs. 1 bd. vol.
Iron and Steel Inst. 1 bd. vol.
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Landreth, W. B. 1 pam.
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Lewis, C. McK. 1 bd. vol.
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Mass. Inst. of Tech. 1 vol.
Midland Ry. Co. 1 pam.
Miller, R. P. 1 bd. vol. 2 pam.
Municipal Engrs. of the City of New York. 1 bd. vol.
New Bedford, Mass.—Water Board. 1 pam.
New England Cotton Mfg. Assoc. 1 bd. vol.
Newlands, F. G. 1 pam.
New York State Museum. 1 vol.
North, E. P. 1 vol., 1 pam., 1 bd. vol.
Platt, T. C. 1 bd. vol.
U. S. Bureau of Forestry. 2 pam.
U. S. Bureau of Plant Industry. 1 pam.
U. S. Bureau of Statistics. 2 vol., 3 pam.
U. S. Chief of Engrs. 5 bd. vol.
U. S. Coast and Geodetic Surv. 1 bd. vol.
U. S. Engrs. School of Application. 3 pam.
U. S. Geol. Surv. 3 vol.
U. S. Interstate Commerce Comm. 2 pam.
U. S. Library of Congress. 1 bd. vol.
U. S. Lighthouse Board. 1 vol.
U. S. Naval Observatory. 1 bd. vol.
U. S. Office of Exper. Stations. 1 pam.
U. S. Weather Bureau. 1 pam.
Univ. of Ill. 3 pam.
Vermont—State Geol. 1 bd. vol.
Von Geldern, Otto. 1 vol.
Washington—Bureau of Labor. 1 vol.
Wellcome, H. S. 2 pam.
Weston, E. B. 1 pam.
Wilgus, W. J. 2 bd. vol.
Wilmington, Del.—Park Commrs. 1 pam.
Worcester Pol. Inst. 1 vol.

BY PURCHASE.

Die Entwickelung des Niederrheinisch-Westfälischen Steinkohlen-Bergbaues in der Zweiten Hälfte des 19 Jahrhunderts. Vol. 10-12. Wirtschaftliche Entwickelung, Teil 1-3. Berlin, Julius Springer, 1904.

SUMMARY OF ACCESSIONS.

February 8th to March 7th, 1905.

Donations (including 4 duplicates)	122
By purchase	1
Total	123

MEMBERSHIP.

ADDITIONS.

		Date of Membership.
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Adams, Edwin Griggs, Jr. Cons. Civ. and Mech. Engr. (Adams & Knowles), No. 2 The Bund, Tientsin, China	Assoc. M. M.	Jan. 1, 1896 Jan. 31, 1905
Brohm, William Carl. Chf. Engr., Grainger & Co., 1632 Second St., Louisville, Ky		Feb. 1, 1905
Brown, Maurice Fritchley. Chf. Engr., Boston Bridge Works, 47 Winter St., Boston, Mass	Assoc. M. M.	Mar. 4, 1903 Feb. 28, 1905
Davis, Charles Stratton. Care, The Massillon Bridge Co., Toledo, Ohio		Feb. 1, 1905
Furman, Job Rockfield. Engr., Otis Elevator Co., 71 Broadway, New York City	Jun. M.	July 2, 1890 Dec. 7, 1904
Hardy, George Fiske. 309 Broadway, New York City		Mar. 1, 1905
Humphreys, Charles. Asst. Engr., U. S. Engr. Dept., 47 Fifteenth St., Wheeling, W. Va		Feb. 1, 1905
Knapp, Hermann Meriwether. Contr. Mgr., Am. Bridge Co. of New York, Union Trust Bldg., Cincinnati, Ohio	Assoc. M. M.	May 6, 1903 Jan. 31, 1905
Lilly, George Washington. Asst. Engr., Dept. of Public Service, Columbus, Ohio.	Assoc. M. M.	April 2, 1902 Jan. 31, 1905
Matthes, Gerard Hendrik. U. S. Reclamation Service, Phœnix, Ariz	Assoc. M. M.	June 6, 1900 Jan. 31, 1905
Millard, Charles Sterling. Engr., M. of W., Peoria & Eastern Ry., Indianapolis, Ind	Jun. Assoc. M. M.	May 2, 1899 June 5, 1901 Jan. 31, 1905
Nichols, Charles Henry. Cons. Engr., and Engr. of Connecticut Shell Fish Comm., 303 Exchange Bldg., New Haven, Conn.	Jun. Assoc. M. M.	May 2, 1893 May 2, 1900 Feb. 28, 1905
Rockwood, Arthur Jones. 43 Triangle Blk., Rochester, N. Y		Feb. 1, 1905
Wall, Edward Everett. Prin. Asst. Engr., Water-Works Extension, 77 East May St., St. Louis, Mo.		Feb. 1, 1905
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Brown, Rodman Merritt. Care, John S. Metcalf Co., 623 The Temple, Chicago, Ill.		Feb. 1, 1905
Carter, Frank Harvie. Asst. to Leonard Metcalf, 14 Beacon St., Boston, Mass		Jan. 4, 190
Chase, Russell. Care, William Hood, Chf. Engr., S. P. Co., San Francisco, Cal		Feb. 1, 1905
Crosett, James Haven. P. O. Box 117, Exeter, Cal		Jan. 4, 1905

	Date of Membership.
Forchhammer, Herluf Trolle. 61 South 11th St., Newark, N. J.	Feb. 1, 1905
Greenwood, Albert Henry. 184 Jackson St., Lawrence, Mass.	Feb. 1, 1905
Griffin, Arthur James. 2149 Clarendon Rd., Brooklyn, N. Y.	Dec. 7, 1904
Hitchman, Jackson Colborn. Chf. Engr., Tuxpam-Tampico Canal, Tampico, Tams., Mexico	Oct. 5, 1904
Holbrook, Frank Dudley. Wellsburg, W. Va.	Feb. 1, 1905
Hubbard, Isaac Wendell. 1334 Real Estate Trust Bldg., Philadelphia, Pa.	Mar. 1, 1905
Lane, Harry Alfred. Room 8, Walsh Bldg., Cumberland, Md.	Feb. 1, 1905
Meyers, Alfred Moyer. Contr. Engr., 718 Dwight Bldg., Kansas City, Mo.	Oct. 5, 1904
Mould, George Alexander Hutchings. Box 4566, Johannesburg, South Africa	Dec. 7, 1904
Myers, Chester John. Care, Water Dept., Atlantic City, N. J. Jun. Assoc. M.	Oct. 1, 1901 Jan. 4, 1905
Newell, Herbert Damon. U. S. Geological Survey, Reclamation Service, Pendleton, Ore.	Dec. 7, 1904
Osborne, George Frederick Folger. Lieut., Royal Engrs.; Asst. Engr., Public Works Dept. (Rys.), Govt. of India; Address, King, King & Co., Fort, Bombay, India	Dec. 7, 1904
Perry, Chauncy Rusch. 47 Winter St., Boston, Mass.	Feb. 1, 1905
Sanderson, Nathan Herbert. 47 Winter St., Boston, Mass.	Feb. 1, 1905

ASSOCIATES.

Usina, Domingo Anthony. Counselor at Law, 170 Broadway, New York City	Mar. 1, 1905

JUNIORS.

Deutschbein, Harry Johnson. City Engr.'s Office, Albany, N. Y.	Dec. 6, 1904
Ferradas, Ramiro Francisco Antonio. Care, Hering & Fuller, 170 Broadway, New York City	Jan. 3, 1905
Follansbee, Robert. Care, U. S. Geological Survey, Washington, D. C.	Nov. 1, 1904
Hartman, Alfred Hanson. Elkton, Md.	Dec. 6, 1904
McCornack, Clyde Webster. Phœnixville, Pa.	Jan. 31, 1905
Moss, Robert Faulkner. Manila, Philippine Islands	Nov. 1, 1904
Pellissier, George Edward. 261 Dwight St., Holyoke, Mass.	Feb. 28, 1905
Reichardt, Walter Frederick. 1201 Welch St., Little Rock, Ark.	Jan. 31, 1905

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WILCOX, FRANK LESLIE	5042 Fairmount Ave., St. Louis, Mo.

DEATHS.

BASSELL, BURR	Elected Member, November 4th, 1903; died February 24th, 1905.
CONSTABLE, CASIMIR	Elected Member, June 17th, 1868; died February 6th, 1905.

MONTHLY LIST OF RECENT ENGINEERING ARTICLES OF INTEREST.

(February 4th, 1905, to March 4th, 1905.)

NOTE.—*This list is published for the purpose of placing before the members of the Society, the titles of current engineering articles, which can be referred to in any available engineering library, or can be procured by addressing the publication directly, the address and price being given wherever possible.*

LIST OF PUBLICATIONS.

In the subjoined list of articles references are given by the number prefixed to each journal in this list.

(1) *Journal*, Assoc. Eng. Soc., 257 South Fourth St., Philadelphia, Pa., 30c.

(2) *Proceedings*, Engrs. Club of Phila., 1122 Girard St., Philadelphia, Pa.

(3) *Journal*, Franklin Inst., Philadelphia, Pa., 50c.

(4) *Journal*, Western Soc. of Engrs., Monadnock Block, Chicago, Ill.

(5) *Transactions*, Can. Soc. C. E., Montreal, Que., Canada.

(6) *School of Mines Quarterly*, Columbia Univ., New York City, 50c.

(7) *Technology Quarterly*, Mass. Inst. Tech., Boston, Mass., 75c.

(8) *Stevens Institute Indicator*, Stevens Inst., Hoboken, N. J., 50c.

(9) *Engineering Magazine*, New York City, 25c.

(10) *Cassier's Magazine*, New York City, 25c.

(11) *Engineering* (London), W. H. Wiley, New York City, 25c.

(12) *The Engineer* (London), International News Co., New York City, 35c.

(13) *Engineering News*, New York City, 15c.

(14) *The Engineering Record*, New York City, 12c.

(15) *Railroad Gazette*, New York City, 10c.

(16) *Engineering and Mining Journal*, New York City, 15c.

(17) *Street Railway Journal*, New York City, 35c.

(18) *Railway and Engineering Review*, Chicago, Ill., 10c.

(19) *Scientific American Supplement*, New York City, 10c.

(20) *Iron Age*, New York City, 10c.

(21) *Railway Engineer*, London, England, 25c.

(22) *Iron and Coal Trades Review*, London, England, 25c.

(23) *Bulletin*, American Iron and Steel Assoc., Philadelphia, Pa.

(24) *American Gas Light Journal*, New York City, 10c.

(25) *American Engineer*, New York City, 20c.

(26) *Electrical Review*, London, England.

(27) *Electrical World and Engineer*, New York City, 10c.

(28) *Journal*, New England Water-Works Assoc., Boston, $1.

(29) *Journal*, Society of Arts, London, England, 15c.

(30) *Annales des Travaux Publics de Belgique*, Brussels, Belgium.

(31) *Annales de l'Assoc. des Ing. Sortis des Ecole Speciales de Gand*. Brussels, Belgium.

(32) *Memoires et Compte Rendu des Travaux*, Soc. Ing. Civ. de France, Paris, France.

(33) *Le Genie Civil*, Paris, France.

(34) *Portefouille Economique des Machines*, Paris, France.

(35) *Nouvelles Annales de la Construction*, Paris, France.

(36) *La Revue Technique*, Paris, France.

(37) *Revicw de Mecanique*, Paris, France.

(38) *Revue Generale des Chemins de Fer et des Tramways*, Paris, France.

(39) *Railway Master Mechanic*, Chicago, Ill., 10c.

(40) *Railway Age*, Chicago, Ill., 10c.

(41) *Modern Machinery*, Chicago, Ill., 10c.

(42) *Transactions*, Am. Inst. Elect. Engrs., New York City, 50c.

(43) *Annales des Ponts et Chaussees*, Paris, France.

(44) *Journal*, Military Service Institution, Governor's Island, New York Harbor, 50c.

(45) *Mines and Minerals*, Scranton, Pa., 20c.

(46) *Scientific American*, New York City, 8c.

(47) *Mechanical Engineer*, Manchester, England.

(48) *Zeitschrift*, Verein Deutscher Ingenieure, Berlin, Germany.

(49) *Zeitschrift für Bauwesen*, Berlin, Germany.

(50) *Stahl und Eisen*, Düsseldorf, Germany.

(51) *Deutsche Bauzeitung*, Berlin, Germany.

(52) *Rigasche Industrie-Zeitung*, Riga, Russia.

(53) *Zeitschrift*, Oesterreichischer Ingenieur und Architekten Verein, Vienna, Austria.

(54) *Transactions*, Am. Soc. C. E., New York City, $5.

(55) *Transactions*, Am. Soc. M. E., New York City, $10.
(56) *Transactions*, Am. Inst. Min. Engrs., New York City, $5.
(57) *Colliery Guardian*, London, England.
(58) *Proceedings*, Eng. Soc. W. Pa., 410 Penn Ave., Pittsburg, Pa., 50c.
(59) *Transactions*, Mining Inst. of Scotland, London and Newcastle-upon-Tyne, England.
(60) *Municipal Engineering*, Indianapolis, Ind., 25c.
(61) *Proceedings*, Western Railway Club, 225 Dearborn St., Chicago, Ill., 25c.
(62) *American Manufacturer and Iron World*, 59 Ninth St., Pittsburg, Pa.
(63) *Minutes of Proceedings*, Inst. C. E. London, England.
(64) *Power*, New York City, 20c.
(65) *Official Proceedings*, New York Railroad Club, Brooklyn, N. Y., 15c.
(66) *Journal of Gas Lighting*, London, England, 15c.
(67) *Cement and Engineering News*, Chicago, Ill., 25c.
(68) *Mining Journal*, London, England.
(69) *Mill Owners*, New York City, 10c.
(70) *Engineering Review*, New York City, 10c.
(71) *Journal*, Iron and Steel Inst., London, England.
(72) *Street Railway Review*, Chicago, 30c.
(73) *Electrician*, London, England, 18c.
(74) *Transactions*, Inst. of Min. and Metal., London, England.
(75) *Proceedings*, Inst. of Mech. Engrs., London, England.
(76) *Brick*, Chicago, 10c.
(77) *Journal*, Inst. Elec. Engrs., London, England.
(78) *Beton und Eisen*, Vienna, Austria.
(79) *Forscherarbeiten*, Vienna, Austria.
(80) *Tonindustrie-Zeitung*, Berlin, Germany.
(81) *Zeitschrift fur Architektur und Ingenieurwesen*, Wiesbaden, Germany.
(82) *Dinglers Polytechnisches Journal*, Berlin, Germany.

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An Improved Detail for Lateral Connections.* (14) Feb. 11.
The Moline Bridge.* (14) Feb. 11.
The Computation of Stresses in the Blackwell's Island Bridge.* R. C. Strachan. (Paper read before the Brooklyn Engineers' Club.) (13) Feb. 16.
Concrete Floors for Railway Bridges.* (13) Feb. 16.
A Three-Hinged Concrete Steel Arch.* L. A. Keith. (14) Feb. 18.
The World's Largest Concrete-Steel Arch Bridge: The Gruenwald Bridge at Munich.* (13) Feb. 23.
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Reconstructing Piers of a Railroad Bridge in Service.* (14) Mar. 4.
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The Erection of the Quebec Bridge: Building the Longest Span Bridge Undertaken in Any Country.* (14) Mar. 4.
The Viaduct of Fades.* Emile Guarini. (19) Mar. 4.
Notice sur le Pont Suspendu de Bonny-Beaulieu sur la Soire. M. Renardier. (43) 4e Trimestre. 1904.
Pont Suspendu du Bonhomme sur le Blavet (Morbihan).* G. Leinekugel Le Cocq. (33) Serial beginning Feb. 4.
La Suppression du Bois dans les Tabliers des Ponts Suspendus Modernes.* G. Leinekugel Le Cocq. (33) Feb. 18.
Versuche mit Gitterträgern.* Selinger. (78) Pt. 1, 1905.
Strassenbrücke in Eisenbeton über das Aischtal bei Neustadt a. Aisch.* Luft. (51) Feb. 15.

Electrical.

A Method for Determining Rates and Prices for Electric Power.* Frank B. Perry, Jun. M. Am. Soc. M. E. (55) Vol. 25.
Electric Drive.* E. L. Walker. (2) Jan.
The Retardation Method of Measuring Losses in Electric Motors and Generators.* Frederick W. Seringhaus, Jr., and Gerard B. Werner. (6) Jan.
The Telegraphone. Z. B. Babbitt. (3) Jan.
The Nernst Lamp.* E. R. Roberts. (58) Jan.
Null Wattmeter Methods of Measuring Power.* Albert Campbell. (26) Jan. 27.

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* Illustrated.

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Variable Speed Motors.* C. L. Sumpter. (26) Jan. 27.
The Tantalum Lamp.* W. von Bolton and O. Feuerlein. (Paper read before the Elektrotechnischer Verein.) (73) Jan. 27; Abstract (26) Jan. 27.
The Insulation of Armature or Other Coils for High-Tension Apparatus. J. S. Highfield. (73) Jan. 27; (26) Jan. 27.
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Automatic Voltage Regulators.* (73) Jan. 27.
The Ionic Theory of the Arc and Spark.* Henry Crew. (4) Feb.
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Colchester Electricity Supply and Electric Tramways.* (26) Feb. 3.
Discriminating Relays and Cut-Outs: a Reply to Mr. M. B. Field. Leonard Andrews. (26) Feb. 3.
Power Plants in Parallel.* R. F. Hayward. (Abstract of Paper read before the St. Louis International Elec. Cong.) (73) Feb. 3.
Development of the Pollak-Virag Writing Telegraph. (73) Feb. 3.
The Turbine Power Station of the Terre Haute Traction & Light Co.* (14) Feb. 4.
A Canadian Municipal Telephone Plant. (27) Feb. 4.
The Stanley Rotated Jewel Bearing Wattmeter.* (27) Feb. 4.
The Use of Sensitive Quadrant Electrometers.* J. C. McLennan. (Abstract of Paper contributed to the Amer. Assoc. for the Advancement of Science.) (27) Feb. 4.
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100-Ton Ladle Crane.* (12) Feb. 10.
Some Tests Conducted with an Electrolytic Rectifier and Motor-Generator.* Horace Boot, M. Inst. E. E. (26) Feb. 10.
Electrical Installations of the Natal Government Railways, South Africa.* (26) Feb. 10.
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Paralleling a 5 500-KW Turbo-Alternator. (From the *Electric Club Journal.*) (27) Feb. 11.
The Electrical Equipment of the Hotel Astor, New York.* W. E. Crane. (27) Feb. 11.
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The Successful Joint Utilization of Several Small Water Powers. W. B. Jackson. (24) Feb. 13.
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The Conversion of a Telephone Exchange from the Magnets to the Central Battery System.* B. S. Cohen. (26) Serial beginning Feb. 17.
Modern Overhead Transmission Lines.* G. Semenza. (Abstract of Paper read before the Assoz. Elettro. Ital. tr. by John R. Dick.) (73) Feb. 17.
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The Dutch Point Plant of the Hartford Electric Light Company.* (14) Feb. 25.
The Power Plants of the Edison Electric Company, of Los Angeles.* (14) Serial beginning Feb. 25.
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Expression des Puissances Fournies par Deux Alternateurs en Parallèle. C. F. Guilbert. (36) Serial beginning Feb. 10.

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Future of Turbine Propulsion. Hon. C. A. Parsons. (Abstract of Address before the Inst. of Marine Engrs.) (47) Jan. 28.

The New Scouts for the King's Navy.* (11) Feb. 3.

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Details of Electric Steering-Gear of the Turbine Steamer *Manxman.** (11) Feb. 17.

Closing Bulkhead Doors by Electricity.* (27) Feb. 18.

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The Construction of the Charleston Dry Dock: A Description of Difficult Foundation Work.* (14) Mar. 4.

Comparaison des Turbines à Vapeur et des Machines Alternatives pour la Propulsion des Navires de Guerre.* (33) Jan. 28.

Mechanical.

Slide Rules for the Machine Shop as a Part of the Taylor System of Management.* Carl G. Barth, M. Am. Soc. M. E. (55) Vol. 25.

Suggestions for Shop Construction.* F. A. Scheffler, M. Am. Soc. M. E. (55) Vol. 25.

What are the New Machine Tools To Be? John E. Sweet, M. Am. Soc. M. E. (55) Vol. 25.

Air Motors and Air Hammers: Apparatus and Methods for Testing.* Max H. Wickhorst, Jun. M. Am. Soc. M. E. (55) Vol. 25.

An Improvement in Valve-Motion of Duplex Air Compressors.* Sterling H. Bunnell, Jun. M. Am. Soc. M. E. (55) Vol. 25.

Tests of a Direct Connected Eight-Foot Fan and Engine.* E. S. Farwell, M. Am. Soc. M. E. (55) Vol. 25.

A Series Distilling Apparatus of High Efficiency.* W. F. M. Goss, M. Am. Soc. M. E. (55) Vol. 25.

The Pressure Temperature Curve of Sulphurous Anhydride (SO^2). Edward F. Miller, M. Am. Soc. M. E. (55) Vol. 25.

Construction and Efficiency of a Fleming Four-valve Engine Directly Connected to 400 KW. Generator.* Benjamin T. Allen, M. Am. Soc. M. E. (55) Vol. 25.

A Compact Gas Engine: Beam Type.* C. H. Morgan, M. Am. Soc. M. E. (55) Vol. 25.

Tests of a Compound Engine Using Super-Heated Steam.* D. S. Jacobus, M. Am. Soc. M. E. (55) Vol. 25.

Standard Unit of Refrigeration. J. C. Bertsch, M. Am. Soc. M. E. (55) Vol. 25.

Specifications for Boiler Plate, Rivet Steel, Steel Castings and Steel Forgings.* (55) Vol. 25.

The Use of Superheated Steam and of Reheaters in Compound Engines of Large Size. Lionel S. Marks, Assoc. M. Am. Soc. M. E. (55) Vol. 25.

Commercial Gas Engine Testing and Proposed Standard of Comparison.* William P. Flint, M. Am. Soc. M. E. (55) Vol. 25.

Road Tests of Consolidation Freight Locomotives.* E. A. Hitchcock, M. Am. Soc. M. E. (55) Vol. 25.

The Effects of Strain and of Annealing in Aluminium, Antimony, Bismuth, Cadmium, Copper, Lead, Silver, Tin, and Zinc.* William Campbell. (55) Vol. 25.

Experiments with a Lathe-Tool Dynamometer.* J. T. Nicolson, M. Inst. M. E. (55) Vol. 25.

The Power Plant of the Tall Office Building.* James Hollis Wells, M. Am. Soc. M. E. (55) Vol. 25.

Some Theoretical and Practical Considerations in Steam Turbine Work.* Francis Hodgkinson, M. Am. Soc. M. E. (55) Vol. 25.

Different Applications of Steam Turbines.* A. Rateau. (55) Vol. 25.

Cast Iron, Strength, Composition, Specifications.* W. J. Keep, M. Am. Soc. M. E. (55) Vol. 25.

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Mechanical—(Continued).

The Potential Efficiency of Prime Movers.* C. V. Kerr, M. Am. Soc. M. E. (55) Vol. 25.
The Power Plant of Tall Office Buildings. Reginald Pelham Bolton, M. Am. Soc. M. E. (55) Vol. 25.
The Steam Turbine in Modern Engineering.* W. L. R. Emmet, M. Am. Soc. M. E. (55) Vol. 25.
The De Laval Steam Turbine.* E. S. Lea, M. Am. Soc. M. E., and E. Meden. (55) Vol. 25.
The Utilisation of Exhaust Steam, from Engines Acting Intermittently, by Means of Regenerative Steam Accumulators and of Low-Pressure Turbines on the Rateau System.* Emile Demenge. (71) Vol. 66.
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The Junker Gas Calorimeter in Practice.* Carl F. Dietz. (8) Jan.
Physical Characteristics of Certain Bronzes for Steam Uses. Strickland L. Kneass. (3) Jan.
Materials Which Retard the Setting of Portland Cement. R. C. Carpenter, M. Am. Soc. M. E. (Extracts from the *Sibley Journal of Eng.*) (67) Jan. (19) Feb. 11.
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Variable Speed Driving Mechanism for Tools.* (47) Jan. 28.
The Diesel Engine in Electricity Generating Stations. A. J. Lawson. (Abstract of Paper read before the Glasgow Tech. Coll. Scientific Soc.) (47) Jan. 28.
Altering the Capacity of the Measuring-Chambers for Inclined Retorts.* (66) Jan. 31.
The Bunsen Flame, and Methods for the Chemical Determination of Flame Temperatures.* F. Haber and F. Richardt. (From *Journal für Gasbeleuchtung.*) (66) Jan. 31.
The Utilization of Waste Heat from Coke Ovens: The Heat Available and Methods and Apparatus Best Suited for Using It.* (45) Feb.
The Jeanesville Iron Works: A Description of the New Shops Erected, During the Past Year, at Hazleton, Pennsylvania.* (45) Feb.
Bending Stresses in Wire Ropes.* Samuel Diescher. (58) Feb.
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The Dry Mixture of Cement. A. L. Goetzmann. (Paper read before the National Assoc. of Cement Users.) (60) Feb.; (24) Feb. 13.
Hot Blast Heating (in the Clay Working Industries).* G. W. Bissell. (Paper presented before the Iowa Brick and Tile Assoc.) (76) Feb.
Some Difficulties Encountered in the Manufacture of First Class Clay Wares in Iowa. S. W. Beyer. (Paper read before the Iowa Brick and Tile Assoc.) (76) Feb.
The Western Roofing Tile Co., Coffeyville, Kan.* (76) Feb.
The Selection and Care of Machinery. Davis Brown and Charles Burridge. (Paper read before the Illinois Clayworkers' Assoc.) (76) Feb.
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Governor for Turbines.* (11) Feb. 3.
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The Burning of Town Refuse, with Special Reference to the Destructors at Brussels, West Hartlepool, Moss Side, and Westminster. George Watson Leeds, M. Inst. M. E. (55) Vol. 25.
The Bacterial Disposal of Sewage. G. Everett Hill. (3) Jan.
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The Fremont Method of Determining the Fragility of Iron and Steel.* Thorsten Y. Olsen. (2) Jan.

Note on the Summation of Stresses in Certain Structures.* Carl Hering. (2) Jan.

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Le Jaugeage de l'Eau.* N. de Tedesco. (36) Feb. 10.
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Middlesborough Dock Electric and Hydraulic Power Plant.* Vincent L. Raven, M. Inst. M. E. (55) Vol. 25.
A Menace to the New York Harbor Entrance. Lewis M. Haupt. (3) Jan.
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Étude sur l'Emploi du Froid Artificial pour l'Exécution des Batardeaux dans les Écluses de Navigation et pour les Fondations de Divers Ouvrages.* E. Maynard. (36) Jan. 25.
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INSTITUTED 1852.

PAPERS AND DISCUSSIONS.

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A NEW SWING BRIDGE AT COPENHAGEN, DENMARK.

By H. C. V. Moeller, Esq.*

To be Presented April 5th, 1905.

At the end of the past century it was resolved to renew an old wooden draw bridge crossing the southern part of Copenhagen Harbor. The cost of the new bridge was divided between the municipality and the harbor authorities in the proportion of 2 to 1. In the summer of 1901 the piers of the new bridge were completed so far as to allow the erection of the superstructure. All work on the bridge was finished in the spring of 1903, just in time to replace the old structure, which had been seriously crippled in a collision with a steamer.

The bridge is a combined highway and double-track railway bridge, consisting of one center-bearing draw span and six deck plate-girder spans, with one roadway and two sidewalks. The roadway is paved for heavy street traffic, and is provided with two sets of rails, one set of double-track rails for street-railway service and

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* Chief Engineer of the Port of Copenhagen, Denmark.

Note.—These papers are issued before the date set for presentation and discussion. Correspondence is invited from those who cannot be present at the meeting, and may be sent by mail to the Secretary. Discussion, either oral or written, will be published in a subsequent number of *Proceedings*, and, when finally closed, the papers, with discussion in full, will be published in *Transactions*.

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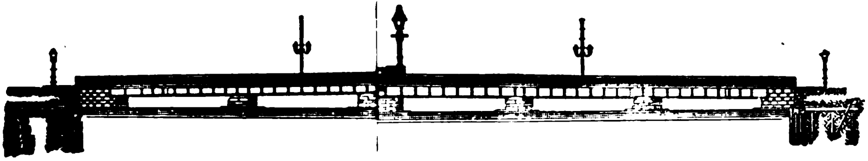
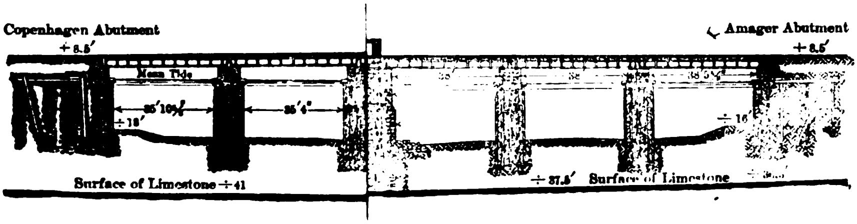
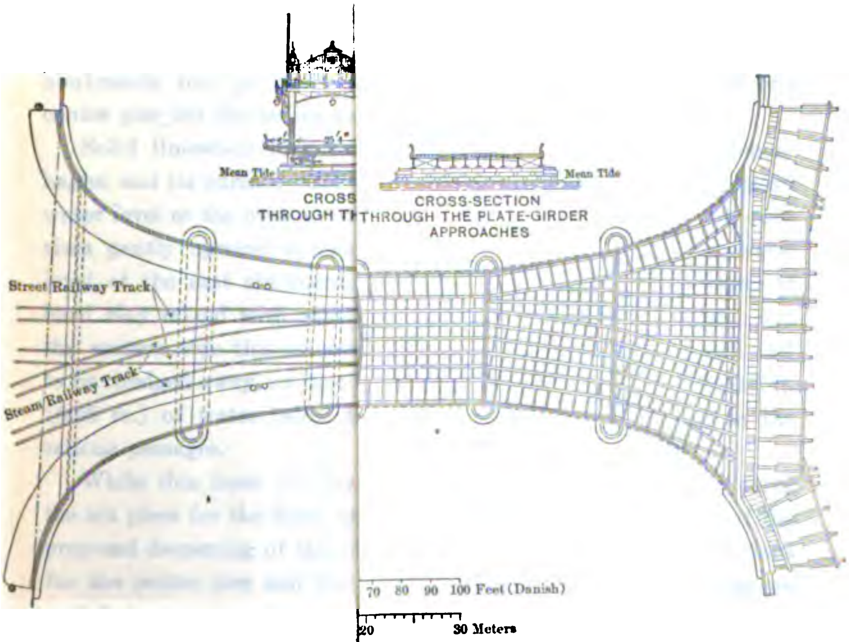
MARCH, 1905.
MOELLER ON
COPENHAGEN SWING BRIDGE.







another set adjacent to them for steam-railway traffic. The steam-railway tracks approach the bridge on a curve with a radius of 300 ft. Each of the two openings of the draw span have a clear width of about 72 ft.

General Dimensions of the Bridge.—The whole length from shore to shore in this part of the harbor is 514.9 ft. (156.9 m.), of which the length of the movable part is 220.3 ft. (67.12. m.). The roadway is 27.2 ft. (8.29 m.) wide, except at the ends, where it is widened on account of the railway tracks forming a **Y** on the bridge so as to connect with the tracks in the adjoining quay streets. On both sides of the roadway there are sidewalks 10.3 ft. (3.14 m.) wide, of which about 2 ft. in width is occupied by the trusses of the movable span. At the shore piers the roadway is 8.57 ft. (2.67 m.) above mean water level, and rises from here, on a grade of 1 in 70, to the center of the swing span. The clear height below this part of the bridge is 8.75 ft. between mean water level and the lowest part of the bridge in the center of each sailing passage.

The Substructure.—The bridge rests upon nine piers, *viz.,* two abutments, four piers for the fixed spans, two end piers and one center pier for the swing span.

Solid limestone rock extends under the whole city of Copenhagen and its surface rises to about 41.2 ft. (12.55 m.) below mean water level at the west abutment; from there the surface of the rock rises gently upward to about 38 ft. (11.6 m.) below mean water level at the east abutment. The rock is covered with a layer of hard clay mixed with sand and limestone about 10 ft. thick. On the eastern side this is covered with a layer of gravel, which had to be dredged away, so that there was everywhere a depth of 20.6 ft. (6.28 m.) of water below the bridge and 22.7 ft. (6.9 m.) in the sailing passages.

While this layer of clay was deemed sufficiently solid to carry the six piers for the fixed spans, it was necessary, on account of the proposed deepening of the sailing passages, to place the foundations for the center pier and the two end piers for the swing bridge on rock bottom.

The Center Pier.—Besides serving as a support for the swing span, the center pier is designed to give room for the hydraulic operating machinery. This explains its oval shape, 30.9 ft. (9.41 m.)

in width and 63.9 ft. (19.46 m.) in length, up and down stream. The pier has semi-circular ends of the same diameter as the width of the pier. The center pier thus provides space for the pivot-room below the vertical axis of the bridge, the accumulator-room in the southern part of the pier, with its floor 16 ft. (4.86 m.) below mean water level, and for a passageway, 5 ft. (1.57 m.) wide, between these rooms.

The center pier had to be placed in a very exposed position, as ships passing through the old bridge were brought close up to the western side of the center pier for the new bridge; dry work inside the coffer-dams, therefore, was entirely out of the question. The pier was built "floating," at a convenient point, by which means navigation was disturbed as little as possible, and the danger due to collisions between boats and the pier was reduced to a minimum.

At first a strong chamber-shaped iron platform was built on a slip, this platform forming the bottom of the floating, hollow pier during its construction. Later, as the outer walls of the pier were raised, it sunk deeper and deeper, the weight of the brickwork and the iron bottom always balancing the buoyancy.

As it was necessary that the masonry be placed so as to weigh down the pier in equilibrium, and at the same time resist the greatest pressure caused by the water, and eventually the impact of blows against the sides of the pier, the masonry was arranged as a ring wall, consisting of horizontal arches supported by three transverse walls, *viz.*, one at the center and two through the center of the circular ends. The ring wall, on both sides of the pier, was divided by the transverse walls into two flat arches of brickwork. The ring wall was of clinker bricks, and the transverse walls and the rear part of the masonry were of concrete.

The pier was constructed in the northern part of the harbor. When the floating pier had sunk to a depth of 16.5 ft. (4.7 m), it was towed to the site and lowered into place. The material above the rock had been excavated by a dredge and leveled off as far as possible by exploding small blasts. The pier was then held by strong moorings and the masonry work continued until the lower edge of the pier was within about 5 ft. of the rock surface. This surface again was cleaned of mud, which had flowed down into the dredged hole during the further construction of the ring wall and

PLATE XXIII.
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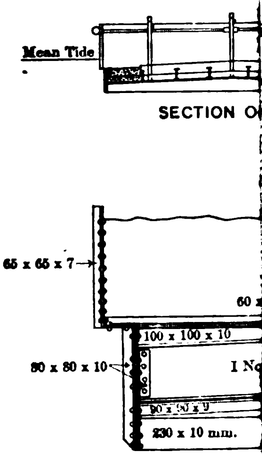
MOELLER ON
COPENHAGEN SWING BRIDGE.



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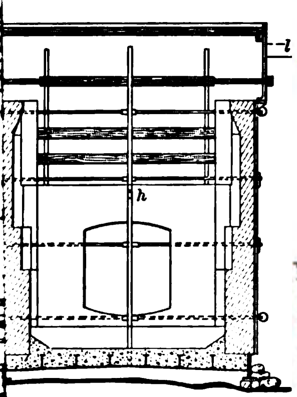

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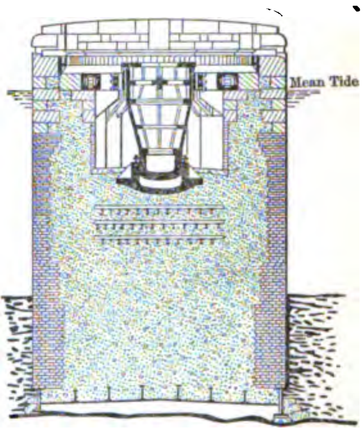

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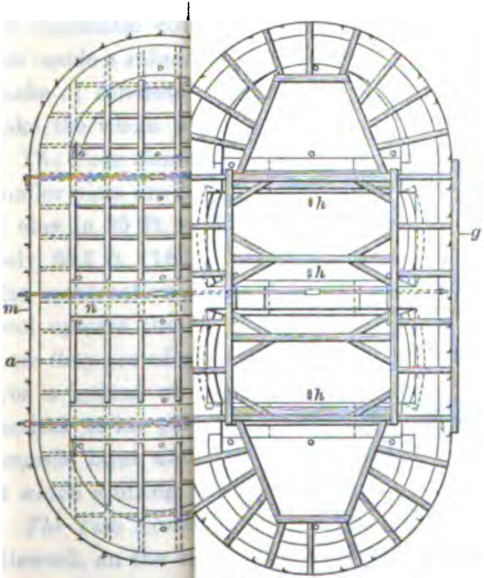

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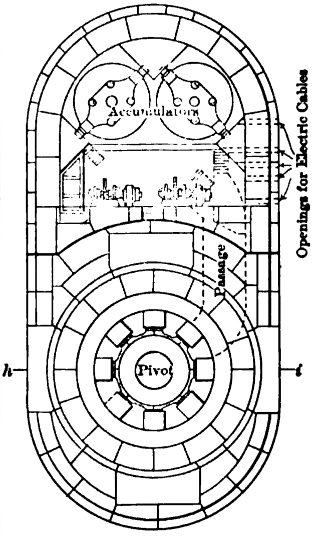
(Danish)

Meters



the transverse walls. The floating pier was then placed in its correct position and sunk to the bottom in less than an hour by filling it with water. Clay and sand were deposited outside and around the foot of the pier to a height of about 12 ft., and the hollow space between the iron bottom of the pier and the rock was filled with neat cement mortar, which was led down through a number of pipes, while the water was led away through vertical pipes. The space inside the ring wall was filled with concrete after the water had been pumped out. The entire weight of the finished center pier is about 11 000 000 lb.

The Two End Piers for the Swing Span.—The end piers are also placed on the surface of the limestone rock, at depths of 38 ft. (11 m.), and 40.2 ft. (12.24 m.) below mean water level, respectively, for the eastern and western piers. The length of each pier is 58.7 ft. (17.89 m.), and their thickness is 9.3 ft. (2.29 m.) at the top, increasing to 14.4 ft. (4.39 m.) at the bottom. They are composed of five horizontal courses of blocks, placed on a concrete foundation cast inside a submarine cylinder placed upon the rock. The different blocks of concrete, with a granite coating, are grooved together to make the whole pier one solid body.

The Four Smaller Piers, Supporting the Fixed Spans.—The four smaller piers are built on a high pilework driven into the firm layer of clay in 20 ft. of water. The lengths of these piers are, respectively, 60.5 ft. (18.36 m.) and 76.8 ft. (23.38 m.), with rounded ends. The construction is the same for all four piers; from mean water level upward the piers have a thickness of 8.2 ft. (2.51 m.), and there they are of granite, resting upon a 2-ft. layer of concrete, cast over a system of wooden piles, in which there are three rows of vertical 12-in. piles and two rows of inclined piles. Outside the concrete layer and the piles a 10-in. pile-planking is placed, inside of which a filling of clay surrounds the bearing and staying piles.

The Two Abutments.—The abutments are constructed on a high pilework, on the same principle as the four smaller piers. They are anchored into the ground by a bulkhead anchorage.

The Superstructure.—The fixed spans of the bridge are supported by a system of shallow girders about 3 ft. (1 m.) in height. Each of the sidewalks is carried by two girders of the same height (3 ft.), upon which steel I-beams are placed. These beams again support a deck of corrugated-plate flooring, filled in with clinkers, and covered by a layer of concrete with an asphalt wearing surface.

On the roadway, the buckle-plates are also covered with a layer of concrete carrying a 2-in. layer of compressed asphalt bricks, with granite curbing along the edge of the sidewalks. The rails of the railway and tramway are fastened to the steel framework of the bridge by underlying bearings, and along both sides of the tramway rails the asphalt is reinforced by a double row of blocks of Australian wood, as these may stand the wear of the wagon wheels better.

The Swing Span.—The swing span is supported by two trusses, the lower parts of which are gently ascending from the ends toward the center, while their upper chords form parabolic curves ascending more rapidly from the ends toward the center. The upper and lower chords are about 2 ft. (63 cm.) wide, and the cross-section is built up of steel plates and angles.

The roadway between the trusses is supported by floor-beams of riveted steel plates and angles, and placed at the verticals of the main girders. These floor-beams are connected by longitudinal beams supporting the buckle-plates. On top of the buckle-plates there is a layer of concrete supporting an oak pavement.

The engine and watch-house is placed on top of the trusses, and contains the necessary machinery for operating the swing span.

General Arrangement of the Machinery for the Swing Span.—When the bridge is closed, the swinging part rests upon six bed-plates, *viz.*, two on each of the two end piers and two on the center pier. The trusses are supported at the center by a heavy cross-girder, resting on a large hydraulic piston—the pivot upon which the bridge turns.

When the bridge is to be opened, the whole movable part, weighing about 850 tons, is lifted about 6 in. (15 cm.) in 15 seconds, resting entirely upon the pivot. It is raised by hydraulic power acting on the pivot, which at the upper end is guided by a collar-bearing, and travels in a low hydraulic cylinder (the pivot cylinder) filled with a mixture of half glycerine and half water. The lifting and lowering of the pivot and the bridge are done by connecting the pivot cylinder alternately, by hydraulic pipes, with heavily and lightly loaded accumulators, so that the fluid is either forced into or carried away from the pivot cylinder.

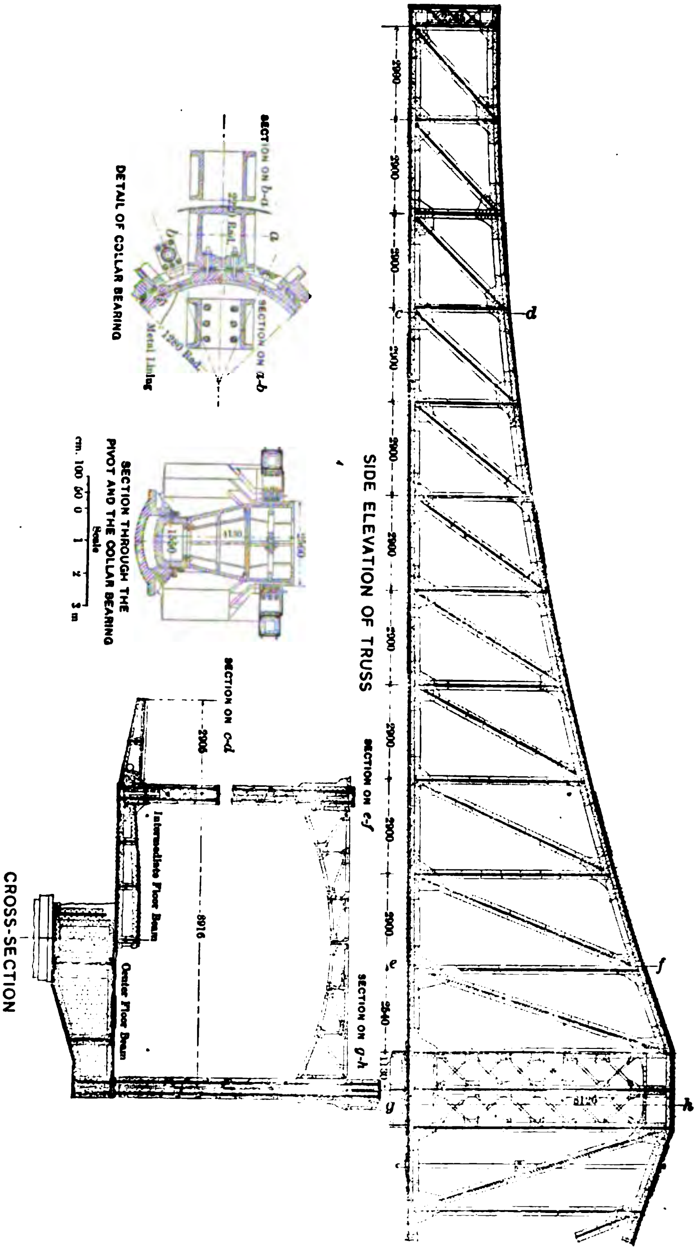

SIDE ELEVATION OF TRUSS
SECTION ON e-f
SECTION ON g-h
SECTION ON c-d
c
d
e
f
g
h
2000
2540
1130
6120
2006
8916
Intermediate Floor Beam
Outer Floor Beam
CROSS-SECTION
SECTION ON b-a
SECTION ON a-b
a
b
2220 Rad.
1250 Rad.
Metal Lining
DETAIL OF COLLAR BEARING
1560
1130
1300
SECTION THROUGH THE PIVOT AND THE COLLAR BEARING
Scale
cm. 100 50 0 1 2 3 m

FIG. 1.

The bridge is turned by a pinion fixed to the movable part and geared to a circular rack fixed rigidly to the center pier. This pinion, through a train of gearing, of which part is below the roadway and part is in the engine-house (these two parts being connected with each other by a vertical shaft placed in the trusses), is driven by an electric motor with a normal capacity of 30 h. p., and a maximum capacity of 40 h. p. The motor is placed in the engine-house, on the top of the trusses. There are two independent sets of machinery, arranged symmetrically around the center of the bridge, each capable of turning the bridge one-quarter turn in one minute. Ordinarily, the two sets of machinery work together, thus neutralizing the reactions in opposite directions on the rack rim. The bridge can be turned 180° in each direction.

At each end of the swing span there is a hydraulic buffer fixed to the end piers and arranged in such a manner as to stop the bridge whether it be turned in one direction or the other. By striking against these buffers, the velocity of the bridge is gradually checked and the span adjusted in its right position; each buffer is designed to resist a force of 12 tons. At each end of the swing span there is also a locking gear, operated by the bridge tender in the engine-house, and this secures the bridge in its correct position.

As previously mentioned, the swing span is released from its bed-plates upon the center and end piers by being raised 6 in., while resting upon the hydraulic pivot. Each of the two accumulators, situated in the center pier, is so heavily loaded that its downward movement is sufficient to cause the pivot to rise. When the bridge is to be lowered, connection is opened between the pivot cylinder and the other accumulator, the weight of which is adjusted so that it moves upward while the pivot moves downward. When the bridge on its downward movement comes to the point where its ends bear against the bed-plates upon the end piers, the reactions from these diminish the pressure so as to check the upward movement of the light accumulator, and the bridge is allowed to settle down the small distance (about ½ in.) still left between the bridge and the bed-plates upon the center pier by opening the connection between the pivot cylinder and a return-water tank. Electric pumps force the fluid from the light accumulator and from the return-water tank, respectively, over into the heavy and the light accumulators, in

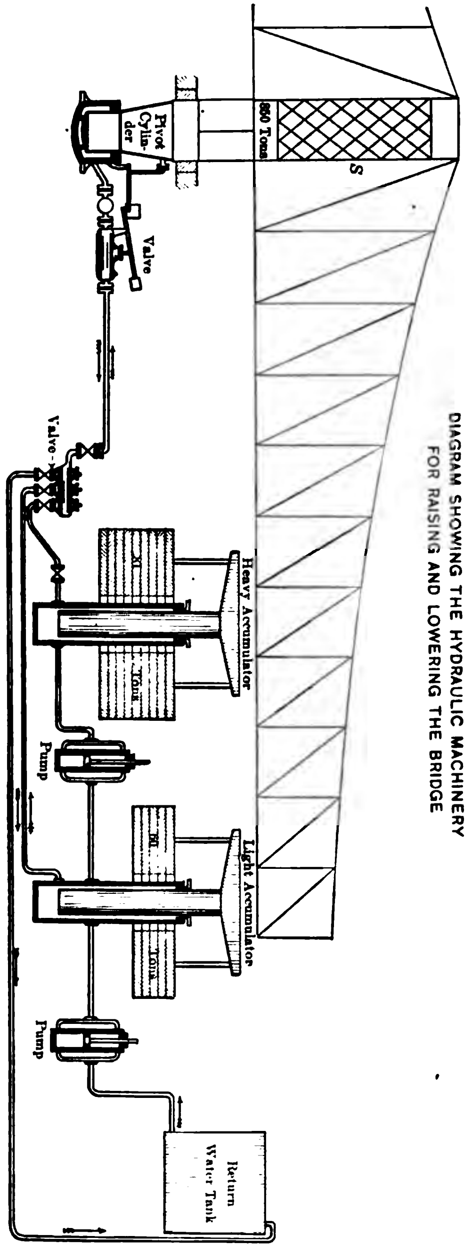


DIAGRAM SHOWING THE HYDRAULIC MACHINERY FOR RAISING AND LOWERING THE BRIDGE

Fig. 2.

order to make everything ready for raising and lowering the swing span again. As will be seen, the work performed in raising the swing span is utilized partly while lowering it; as the fluid-pressure in the pivot cylinder is used to raise an accumulator loaded with 56 tons (39 atmospheres), it being only necessary, by aid of the electric pump, to press the fluid from this accumulator to the other, which is loaded with 76 tons (52½ atmospheres). The small quantity of fluid which is led from the pivot cylinder into the return-water tank is pressed by the reserve pump into the light accumulator. Of course, this machinery works automatically as soon as the heavily loaded accumulator is lowered. The whole operation, until this accumulator is raised again, takes 3 minutes.

The Electric Installation.—The power for the manipulation of the bridge is electricity, delivered from one of the municipal electric stations. There are five cables which cross the western sailing passage and are led through five cast-iron pipes in the side wall of the center pier to a switch-board on the upper floor in the accumulator-room. Two of the electric cables have an electro-motive force of + 220 volts, two of — 220 volts, while the fifth is an 0-cable; (one plus and one minus cable are in reserve, but they are put in service automatically if the acting cables should fail). From the switch-board, the conductors branch off to the pump motors and the lamps in the accumulator-room, and to the pivot-room. The transmission of the current, from the conductors in the center pier to the swing span, is obtained by a system of contacts consisting of five copper contact-rails, shaped as horizontal rings, around the pivot and fixed to it by porcelain insulators, and trolleys running upon these rails, three upon each rail. The trolleys are fastened to arms which, by movable joints, are fixed to the walls of the pivot-room, thus allowing the trolleys to follow the raising and lowering of the pivot and its contact-rails. The upper two of these rails transmit + and — 220 volts to the electric motors for the swinging machinery, and to the arc lights on the bridge, the lower two rails transmit the current necessary for the telephone and alarm apparatus between the bridge tender in the engine-house and his assistant in the accumulator-room, while the center rail serves the circuit of the electric apparatus in the accumulator-room for manipulating the main valve on the connecting pipe between the pivot cylinder and the accumulators from the engine-house. For this transmission the earth serves as the return conductor. From the inner side of the hollow pivot the conductors are led as vulcanized rubber cables with iron armatures through the inner room of the main cross-girder, and from here the cables ascend along the trusses to the switch-board in the engine-house, from which they branch off to the different apparatus.

Loading.—The loads for which the bridge is constructed are as follows: Traffic by persons and carriages—100 lb. per sq. ft.—a truck weighing 20 tons, equally divided upon four wheels with an axle distance of 12 ft. (4 m.); the weight of two locomotives in opposite directions; besides the effect of wind pressure and braking. The weight of one locomotive and tender is 64 tons, the locomotive has three axles, the weight upon the center one being 13 tons and upon each of the two others 12 tons, the distance between the axles being 4 ft. (1.3 m.). The tenders also have three axles spaced 4½ ft. apart (1.5 m.), the load upon each axle being 9 tons. The wind pressure is calculated to reach 34 lb. per sq. ft. when the bridge is loaded, and 54 lb. per sq. ft. when unloaded. During the turning of the swing span, this is calculated as being loaded by a 20-ton truck on one end and exposed to a wind pressure of 34 lb. per sq. ft.

Working Expenses.—The electricity consumed at one opening and closing of the swing span for the passage of a boat has proven to be 4.3 cents, that is, 1.3 cents for the raising and lowering of the span and 3 cents for its turning. The municipal price for motor electricity per hectowatt per hour is about 0.4 cent.

Vol. XXXI. MARCH, 1905. No. 3.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PAPERS AND DISCUSSIONS.

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THE RECONSTRUCTION OF THE BALTIMORE AND OHIO RAILROAD BRIDGE OVER THE OHIO RIVER, AT BENWOOD, WEST VIRGINIA.

By J. E. Greiner, M. Am. Soc. C. E.

To be Presented April 19th, 1905.

The Old Bridge.

The original bridge at this place was built under the general authority given by the Act of Congress approved July 14th, 1862. This Act provided that bridges built over the Ohio River above the mouth of the Big Sandy should not have a less elevation than 90 ft. above low-water mark in the channel, nor a less span than 300 ft. over the main channel, the next adjoining span to be not less than 220 ft.

The bridge was composed of 9 Bollman deck spans, 4 deck spans and 2 through spans of Linville and Piper type, as shown on Plate XXIV, and, in addition thereto, there was an approach on the Ohio side consisting of 43 semi-circular stone arches, with 28 ft. clear span and a total length of approach of 1 490 ft. The length of the iron bridge, from center to center of abutments, is 1 435 ft. 6 in.,

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Note.—These papers are issued before the date set for presentation and discussion. Correspondence is invited from those who cannot be present at the meeting, and may be sent by mail to the Secretary. Discussion, either oral or written, will be published in a subsequent number of *Proceedings*, and, when finally closed, the papers, with discussion in full, will be published in *Transactions*.

PLATE XXIV.
PAPERS, AM. SOC. C. E.
MARCH, 1905.
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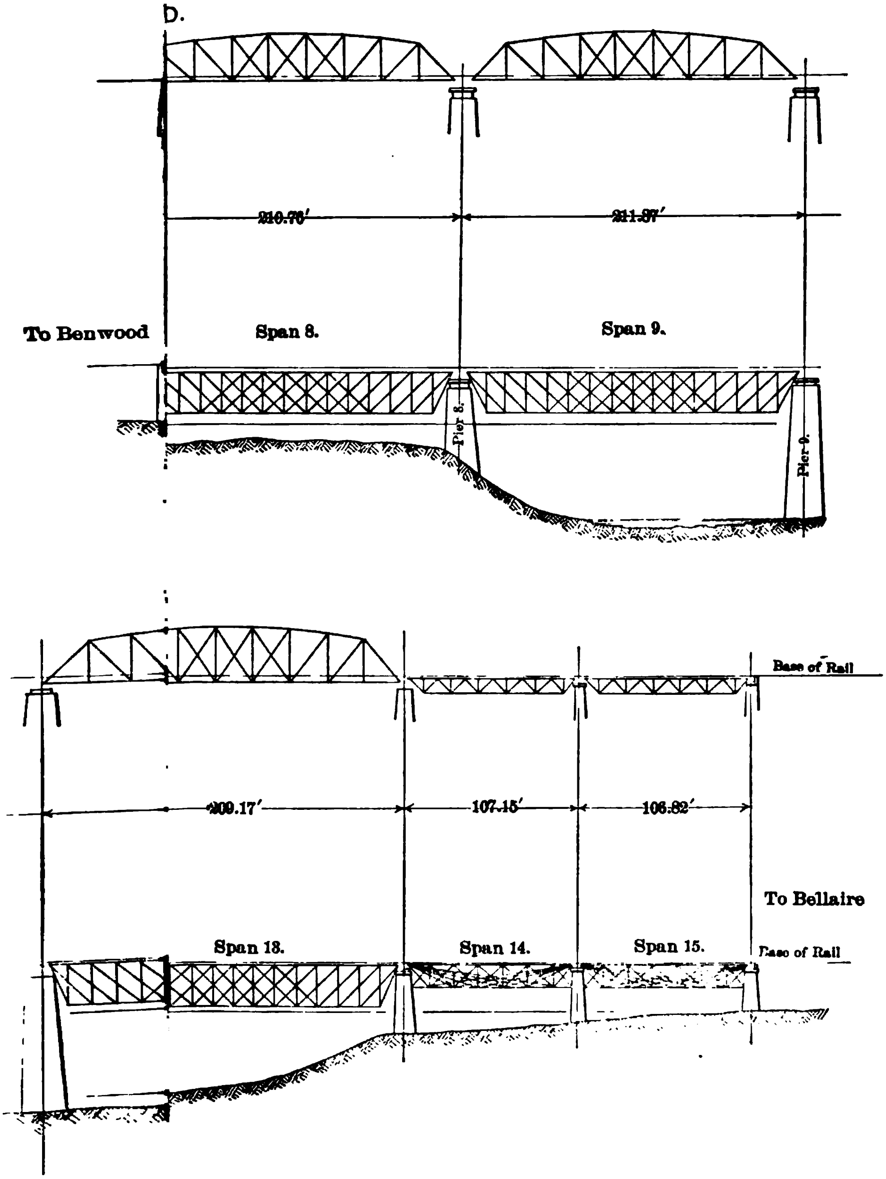
RECONSTRUCTION OF BENWOOD BRIDGE.



and the total length of the entire bridge, including approach, from end to end of masonry, is 3 916 ft. 10 in.

The Bollman spans were built by the Baltimore and Ohio Railroad Company at its Mt. Clare shops, Baltimore. The other spans were built by the Keystone Bridge Company. The first stone was laid in the foundations on May 2d, 1868, and the bridge was opened for traffic on June 21st, 1871.

The structure was designed for a uniform load of about one ton per foot, with the unit strains in use at that time.

PERIODS OF RECONSTRUCTION.

The rebuilding of this bridge was not a continuous operation, but was done in sections extending over a number of years, the policy being to replace those spans which were the most expensive to maintain, or which developed weakness under the existing traffic, in the order in which this weakness was made evident. Each section was designed in accordance with the specification in use on the Baltimore and Ohio Railroad at the time the design was made, the result being that the completed new structure is not of uniform strength.

The periods of renewal were as follows:

Year 1893.—Spans 14 and 15, designed for Consolidation engines weighing 107½ tons with tenders; all material wrought iron; specifications of 1892; Union Bridge Company, builders.

Year 1900.—Spans 1 to 7, inclusive, designed for Consolidation engines weighing 125 tons with tenders; material, soft open-hearth steel; specifications of 1896; builders, Pencoyd Iron Works.

Year 1902.—Spans 8, 9, 10 and 13, designed for Cooper's E-50 engines, followed by a train load of 5 000 lb. per running foot; material, soft open-hearth steel; specifications of 1896; builders, Edgemoor Plant, American Bridge Company.

Year 1904.—Spans 11 and 12, designed for Cooper's E-50 engines; material, open-hearth structural steel; specifications of 1901; builders, Edgemoor Plant, American Bridge Company.

THE DESIGN.

The reconstruction of this bridge, except Spans 11 and 12, involved no work of particular interest, either in the design or in the erection, as there was no objection to the use of falsework. Spans 8, 9, 10 and 13 were made through bridges, instead of deck bridges, as the trusses and overhead bracing could be erected before disturbing the old structure, and in case the falsework had been washed out, there would have been the least possible interruption to traffic.

The design of Spans 11 and 12 was controlled by the proposed method of erection, the requirements being that the erection should be carried on without interrupting the railroad traffic or interfering with navigation in the main channel span (Span 11), there being no objection to falsework under Span 12.

The question of widening the channel was fully considered before the final adoption of the design upon which the structure was actually built. The War Department and the river men desired a much larger channel span than existed in the old structure, but there was a still further question as to who should pay for the difference in cost between rebuilding the bridge on the existing masonry and the lengthening out of the span as desired, the Railroad Company claiming under their charter the right to maintain the bridge on the existing masonry. The Railroad Company had obtained a special War Department permit during 1900 for the reconstruction of Spans 8, 9, 10 and 13 on the existing masonry, and, considering this fact, the War Department would probably have been satisfied with the removal of Pier 11 and the replacing of Spans 11 and 12 with one single span of a total length, from center to center of piers, of 589.48 ft., part of which could have been erected on falsework. This would have required extending Piers 10 and 12 and the removal of Pier 11. A study of this plan is shown in Fig. 1. It is estimated that this single span would have cost about $253 500 more than the construction on the existing masonry.

While the War Department would probably have agreed to a span of 589.48 ft., they preferred a span giving at least 700 ft. in the clear of the piers. This would make a length of 730 ft. from center to center of piers. This would have necessitated the removal of three piers, the lengthening out of one pier, the rebuilding

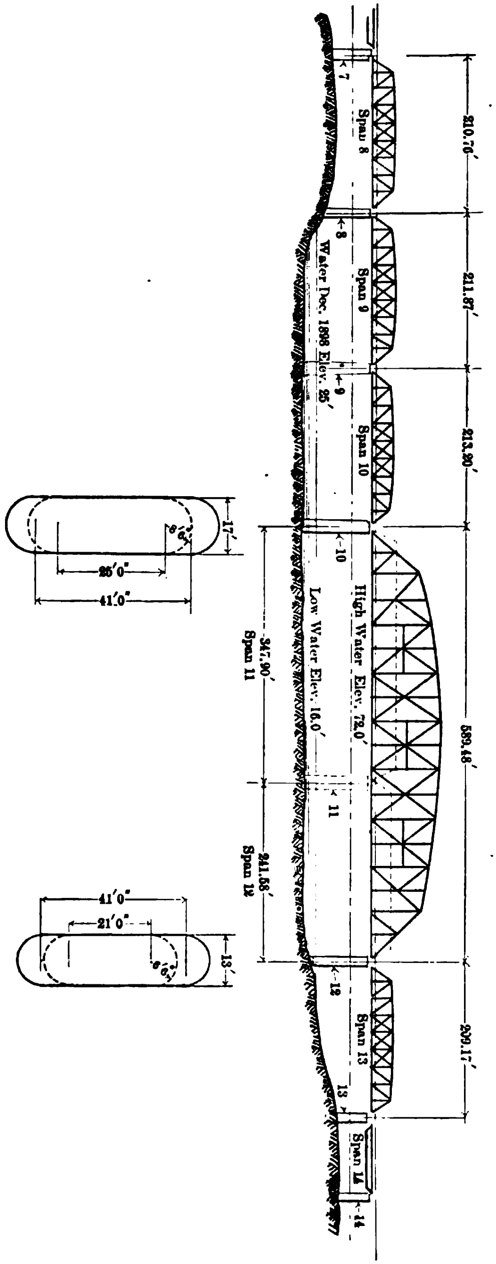

210.76'
211.87'
213.20'
589.48'
209.17'
Span 8
Span 9
Span 10
Span 13
Span 14
7
8
9
10
11
12
13
14
Water Dec. 1898 Elev. 25'
High Water Elev. 72.0'
Low Water Elev. 16.0'
347.90'
Span 11
241.58'
Span 12
17'
25'0"
41'0"
8'6"
41'0"
21'0"
13'
8'6"

FIG. 1.

of one pier, and the replacing of Spans 9, 10, 11 and 12 with one span of 284.55 ft. and one span of 730 ft. A study of this scheme is shown in Fig. 2. It was estimated to cost about $563 000 more than the cost of erecting on the existing masonry.

All the old bridge having been replaced by this time, with the exception of Spans 11 and 12, and the weakness of these spans being such as to prevent the Railroad Company from using the heavy cars and locomotives which were in operation on each side of the bridge, it became necessary for the Railroad Company, in order to get the benefit of their heavy power and equipment, to reconstruct these two spans as speedily as possible, and there being no prospect of the Government or the river men paying the additional cost for the increased channel span, and the Railroad Company not being inclined to bear this extra expense, it was decided to reconstruct these two spans on the existing masonry, care being taken not to interfere with navigation through the main channel. The method of erection, therefore, was the main feature which controlled the design of these spans. As Span 12 could be erected on falsework, this span presented no difficulty, but for Span 11 there were only three apparent methods of erection, as follows:

A.—Extend the piers by means of pile bents, erect the new span on floats, jack the old bridge to one side and float the new span into position, and then pick up the old span with the floats, move it to one side and dismantle it;

B.—Transfer the Baltimore and Ohio traffic over the Wheeling Terminal Bridge, and erect Span 11, using the existing structure in place of falsework;

C.—Erect Span 11 on the cantilever principle, Span 12 to be erected on falsework and designed as one shore arm and a temporary shore arm being placed on the outside of the existing structure in Span 10. In this method, the old Span 11 would be called upon to carry the railroad traffic and at the same time support the erection traveler. Between trains, this old span would support the traveler and such members as the traveler was handling.

Method *A* was abandoned as impracticable, on account of the frequent variation of the water level of the Ohio River.

Method *B* was at first considered favorably on account of the

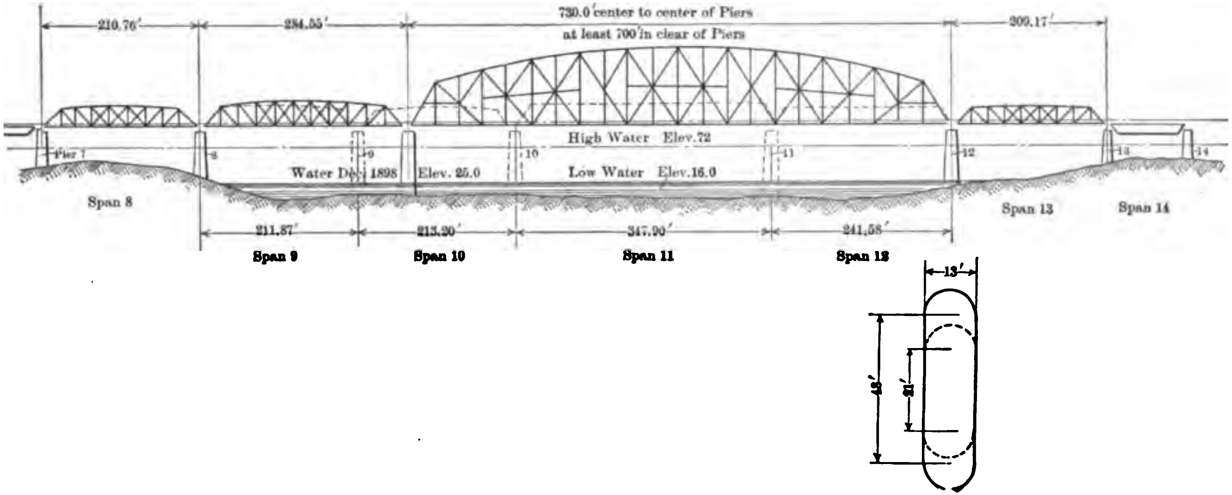

210.76′
284.55′
730.0′ center to center of Piers
at least 700′ in clear of Piers
209.17′
High Water Elev. 72
Water Dec. 1898 Elev. 25.0
Low Water Elev. 16.0
Pier 7
8
9
10
11
12
13
14
Span 8
211.87′
213.20′
347.90′
241.58′
Span 9
Span 10
Span 11
Span 12
Span 13
Span 14
13′
48′
21′

FIG. 2.

possibility of the Baltimore and Ohio Railroad transferring its traffic over the Wheeling Terminal Bridge for a period of 50 or 60 days while Span 11 was being replaced. This scheme was abandoned, on account of the congestion which would result on the Wheeling Terminal Bridge, due to the immense volume of business being done at that time.

It was decided, therefore, to proceed with the erection in accordance with Method *C*. The structure was designed accordingly, and the work was carried through to completion. The following is a brief description of the main features in the design of these two spans:

Span 12 was designed and proportioned so as to take up reversal of stresses while the trusses were acting as cantilever arms during the erection of Span 11.

Span 11 was designed so that the trusses and upper bracing cleared the old span. The floor system and lower laterals, however, could not be made to clear, on account of the fact that the distance from the base of rail to the lowest part of the structure has to remain the same in both cases. The span had a stiff bottom chord throughout, all members, of course, being designed to meet the conditions of erection as a cantilever and as a free span after erection.

As the existing Span 10 was of a good, modern type of construction, it was not desired to replace it. It had eye-bar bottom chords, and could not be made to act as a shore arm during the erection of Span 11, and it became necessary to design special trusses, extending from Pier 9 to Pier 10, which could act as shore arms during the erection of Span 11. These trusses could be erected on the outside of the existing span, and were designed so that they could be inverted and used as a deck bridge after they had served their purpose during the erection of the Benwood Bridge. These erection trusses were to be clamped to the existing span in such a manner that they would be free to move vertically.

The east, or Benwood, end was arranged so that it could be raised or lowered with jacks, as was also the west, or Bellaire, end of Span 12. The erection of Span 11 was to proceed from the piers toward the center, the old truss being relied upon to carry the weight of the traveler and restricted traffic, and the individual members handled by the traveler. The west end of Span 11 was on

PLATE XXV.
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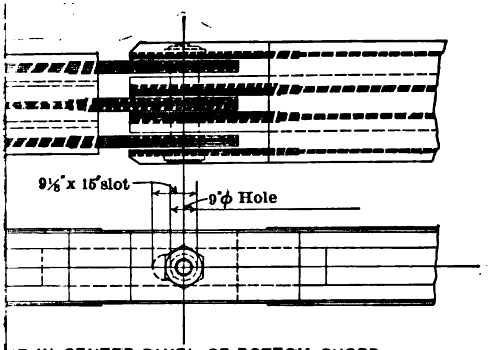
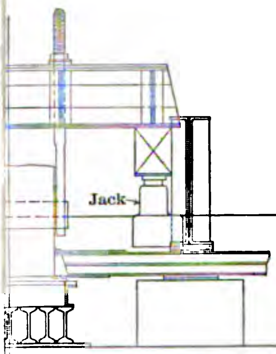
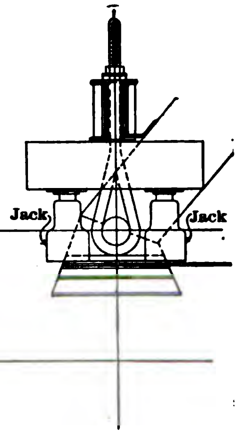
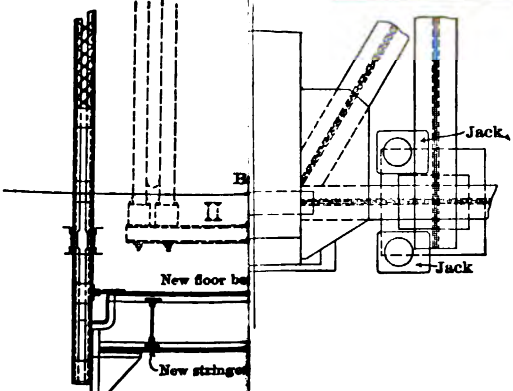


NT IN CENTER PANEL OF BOTTOM CHORD





ARRANGEMENT OF JACKS
W. END SPAN 12.



SPAN 11. CROSS-SECT

rollers. Attached to the end bottom pins at this end were struts which connected with cross-girders temporarily attached to Span 12. Each of these struts was in two sections, and these sections bore against a wedge arrangement. An overlap of $2\frac{1}{16}$ in. was provided in the bottom-chord center panel at low temperature, and about 10 in. clearance of the top-chord center panel, at high temperature. The west end of the center bottom chord was provided with a 9-in. slot, with a maximum movement of 4½ in. each way. The wedge struts at the west end provided for a maximum movement of 8 in.

It will be seen from the foregoing description that, by jacking up the east end of Span 10 and lowering the wedges in the strut at the west end of Span 11, the top chords at the center of Span 11 could be lowered to their proper bearing; and, if, by some chance, there should not be sufficient movement attainable with the wedge arrangement there was still left an opportunity of jacking up the west end of Span 12 (see Plate XXV).

THE ERECTION.

The method of erection of Spans 11 and 12 (see Plate XXVI) was carried on as outlined in the following:

Span 12.—Falsework was placed under the old span, which was then taken down. The traffic was carried on this falsework while the new span was being erected. The falsework was not removed until Span 11 was swung, as it was required to support the live load, thereby avoiding vibration in the west half of Span 11 during erection.

The dead-load positive reaction per truss on Span 12 was 157 000 lb., and as the erection-stress negative reaction was only 56 000 lb., no counterweighting was required.

The East Shore Arm. Span 10.—For the east shore arm, the temporary trusses were erected outside of the trusses of Span 10, and on the same line as the trusses in Span 11. They were erected directly from the existing span, without the use of falsework, and were clamped to the existing trusses, the clamps being arranged so as to permit of movement up and down. The east ends of these erection trusses were dropped about 36 in. below the level. The dead-load positive reaction about equalled the erection-stress negative reaction, and, therefore, provision was made for about 25 tons counterweights for each truss.

Span 11.—The erection of this span was started at the east end, and, as the traveler moved toward the center of the span, the portals, top laterals and as much of the sway bracing as possible were removed. The floor-beams were placed upside down, in a temporary position below the bottom chord pins, and connected to the posts, which were lengthened for this purpose and which were cut off after the floor-beams were placed in their proper position. After the east half was completed as far as the center, and all bracing was placed, the west arm was erected in the same manner, connection being made in the center panel of the top and bottom chords.

No difficulty whatever was experienced in connecting the two halves of this span. The east end of Span 10 was jacked up and the wedges at the west end of Span 12 were withdrawn until the members came to their proper position. After this span was swung, the intermediate stringers were placed in their temporary position, under the old trusses, and connected by temporary timber laterals. The old trusses and floor were then blocked up and the trusses and bracing taken down, using the new span for support. The end panels of the laterals were placed in their permanent position, and temporary stringers provided, so as to clear these end laterals.

GENERAL.

The traveler used during this erection, as will be observed from the plan, was run on the top chords of the existing bridge. It weighed 40 tons. Nearly all the material was floated out under the spans on barges, then picked up and placed in position by the traveler.

During the erection of Span 11, it was necessary to take the greatest care in placing the traveler in a fixed position during the handling of material, and, before the erection proceeded, the old bridge was carefully adjusted and the posts braced with temporary wooden braces. The maximum tension strains in the old bridge during this erection did not exceed 16 000 lb. per sq. in., and the compression strains were in proportion.

As Span 11 was considerably wider than the existing bridge, and

PLATE XXVI.
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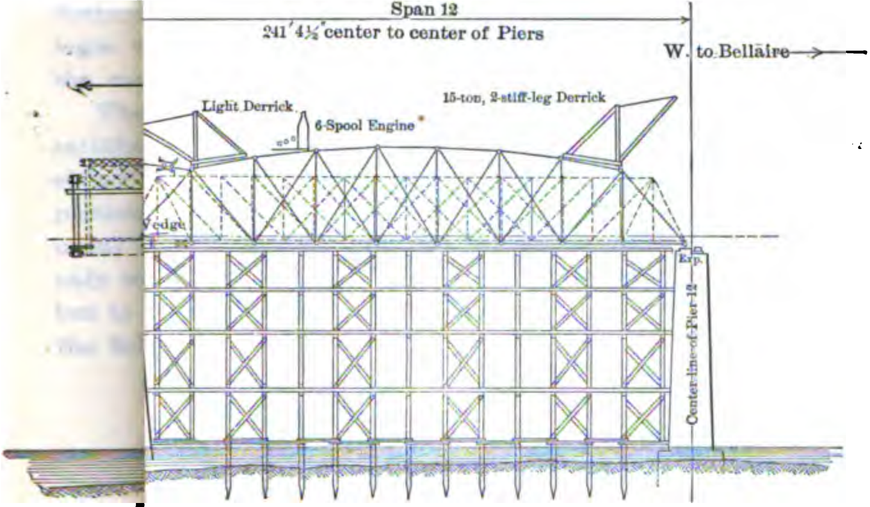

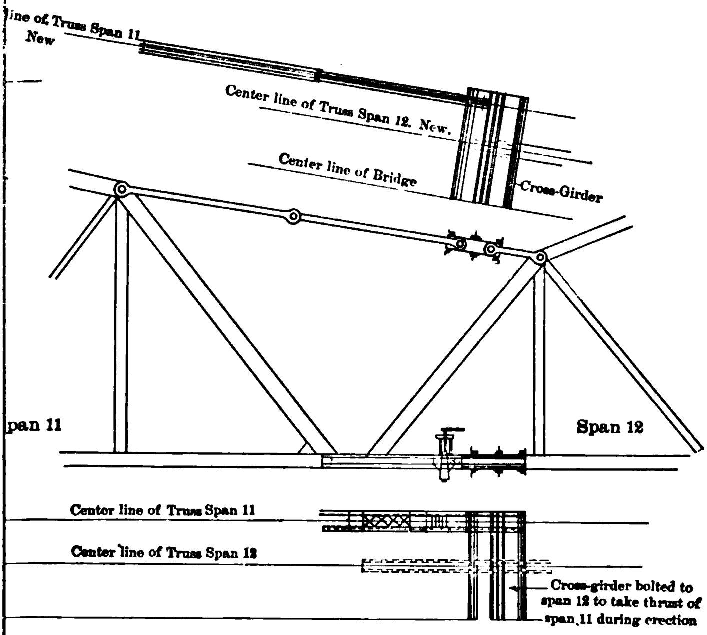
ine of Truss Span 11 New
Center line of Truss Span 12. New.
Center line of Bridge
Cross-Girder
pan 11
Span 12
Center line of Truss Span 11
Center line of Truss Span 12
Cross-girder bolted to span 12 to take thrust of span 11 during erection

as the bearings were rather closer to the ends of the piers than was desired, the masonry was cut down, under traffic, and I-beam grillages were placed on top of the piers, with a view of distributing the weight.

The entire work of erection was conducted in a most careful and satisfactory manner, there being no hitch or errors of any moment, either in workmanship or in judgment, and the successful completion of this dangerous piece of erection, which was of an unusual character, perhaps without precedent, is very creditable, not only to the Erection Department of the American Bridge Company, but to Foreman J. W. Sweet, who had direct charge of the forces in the field.

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THE RECLAMATION OF RIVER DELTAS AND SALT MARSHES.

Discussion.*

BY RICHARD LAMB, M. AM. SOC. C. E.

Mr. Lamb. RICHARD LAMB, M. AM. SOC. C. E.—The speaker would like to know whether the subsidence of the marsh lands on the deltas of the Mississippi are referred to by the author, also, whether the revetment described in the paper occasioned an accretion. It is an engineering fact, not generally known, but which was known to the Romans, as far back as the first centuries, that if a piece of marsh land on the delta of a tidal river is enclosed, there will be a natural accretion of land. Some years ago, on learning of the accretions which had been developed in England, and in making a thorough study of the subject, the speaker made some tests. A barrel was put in the sand in a river where the rise and fall of the tide was about 3 ft., and in a short time the sand came over the top of the barrel, although the general level of the sand was near the bottom of the barrel. Working on that principle, about 50 acres of land at tide water were reclaimed for the Norfolk Terminal Company. The natural accretion was augmented, however, by material excavated from the channel near by.

The Romans, at the time of the invasion of Great Britain, reclaimed thousands of acres of land in "The Wash," on the north

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*Continued from February, 1905, *Proceedings*. See November, 1904, *Proceedings* for paper on this subject by J. Francis Le Baron, M. Am. Soc. C. E.

shores of Norfolk County. Three rivers, the Ouse, the Welland and the Witham, whose courses are very tortuous, empty into this bay. The channels of these rivers were straightened by levees on either side. The levees were built on the concave side first so that the water would scour out ahead of, and make a bed for, the levees. By straightening the courses of the rivers, the general elevation of the water was lowered, reclaiming thereby large areas of land. At the deltas of the rivers revetments were built about areas amounting, in all, to ½ mile by 10 miles. After these revetments were built, the accretions were very marked and steady. First a settlement of sand, then of warp, then a scrubby growth and at last a growth of valuable grasses. These lands were leased at £4 per acre, and much of it was sold at £80 per acre. It is used chiefly for pasture, but is considered the richest of the English agricultural districts. **Mr. Lamb.**

In 1883 the speaker was employed by The Dismal Swamp Land Company, composed of gentlemen, the heirs of George Washington, to make plans for the drainage of the Dismal Swamp. George Washington was granted 40 000 acres of the Dismal Swamp in consideration of his valuable services to his State and Country in the French War. He made surveys of these lands, some of the lines of which the speaker had the pleasure of re-running.

Incidentally, the speaker wishes to remark that, in a discussion as to how a tree grows—he contending that trees do not grow in height, but simply gain by accretion—he stated that in running the lines of George Washington's survey, he found a witness-tree on which the bark showed no marks. On cutting off the bark, three axe marks were found at the height at which a man would naturally have made them. If the tree had grown in height, those axe marks would have been up in the air 70 or 80 ft.

Grubbing a drained swamp land is the greatest expense of reclamation. Grubbing costs at least $30 per acre. The speaker found that after the swamp was drained and enclosed with a fence, by turning in a herd of cattle they grubbed up the land and fertilized it in a few years, and that all that farmers could do, at a cost of $30 per acre, was done by the cattle at practically no cost, when counting the sale of calves and beeves. It would be instructive to know the author's estimate of the cost of grubbing.

It is generally believed that the Dismal Swamp is an unhealthy morass. On the contrary, it is one of the healthiest districts in the State of Virginia. Before the war, when slaves were recuperating from malaria, they were often sent to the Dismal Swamp to cut shingles, in order to regain their health. The juniper water, which abounds everywhere, has the wonderful property of allowing nothing to rot in it. Water taken from the Dismal Swamp has been used for drinking purposes on men-of-war on a 3-year cruise without

Mr. Lamb. getting stale. The speaker has drunk juniper water taken from this swamp, and said to have been for 20 years in the tanks of the old man-of-war, *Constitution*.

It is generally supposed that the Swamp is a dead level, and Lyle, the great geologist, said that its submergence was due to the vast springs therein. After diligent search, the speaker never found one spring there. The Dismal Swamp is on a side hill, and at very few places is the water still. By observing the direction of flow of the water the summit levels of the divides were noted—the water flowing each way from the apex. These streams were followed, and thus the contours were determined and the Swamp divided into drainage areas. At first, before learning these facts, the speaker thought that the Swamp was so level that it would be necessary to use the Elkenton system, *i. e.*, to dig wells and border them with dry rubble. These wells are dug through the impervious clays forming the bed of the water of the Swamp. After passing through these strata, quicksand is reached, at the level of tide water. Naturally, the water passing into these strata would lower the level of the Swamp. However, there is at least a fall of 2 ft. to the mile to the various points at tide-water level about the Dismal Swamp. Therefore the drainage becomes a simple matter.

Reference is made in the paper to the value of rice culture on the reclaimed land. It may be of interest to state that George Washington, who has always been considered a man of great versatility, engaged in the rice business at a point farther north than rice has ever been raised in marsh lands. Of course, high-land rice is raised around there to-day, but swamp rice is not raised north of the southern part of North Carolina. The sluices and embankments of the Washington farm, known as "Paradise Farm," are still to be seen. Within a short distance of this farm, there is a fall of about 14 ft. Here was erected a mill for cleaning the rice and for other purposes. It is said that the rice crops of Paradise Farm were the envy of the farmers of that part of the State. Washington was called away from this profitable business to serve his country. Later, after retiring, in a letter to a friend, he said that it had been his ambition to drain the Dismal Swamp and to continue his operations in that district.

The cost of draining land, as given by the author, is practically the same as that estimated by the speaker for the work in the Dismal Swamp. The lands of this swamp which were drained yielded for years, as far as the speaker knows, and still yield 100 bushels of corn per acre. They are considered the richest in the world. The only form of fertilizer used is a little lime applied when first reclaimed to "sweeten" the soil.

It is an interesting fact that the rice from Virginia, and also that

Mr. Lamb.

from North Carolina, has been used almost exclusively to export for seed for rice culture in China and India; and, even to-day, nearly all the rice of North Carolina is exported for seed, and three-quarters of the rice used in the United States is imported, in spite of the fact that its importation is hazardous from the fact that if there is much movement of the cargo in the boat the husks make the rice too brittle to use. The rice is milled in the United States. This fact insures that the swamp lands of the delta of the Mississippi and many of the arid lands which the Government is now reclaiming will be utilized for rice culture, thus saving the large duty and the great risks of deterioration, and lessening the cost of what may become the staff of life of America as it is of Asiatic countries.

Since the war, rice culture has almost ceased in the South, as it was a business that meant death to hundreds of slaves, it being one of the most unhealthy employments, for the reason that in putting the water on the rice fields and taking off, malarial bacteria are generated. At one place the owner of a piece of property showed the speaker a small grave yard and said, "There is one million dollars of money buried in that little field—dead slaves." With modern machinery to do the plowing and planting, however, the labor difficulty is being overcome.

Vol. XXXI. MARCH, 1905. No. 3.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
INSTITUTED 1852.

PAPERS AND DISCUSSIONS.

This Society is not responsible, as a body, for the facts and opinions advanced in any of its publications.

A RATIONAL FORM OF STIFFENED SUSPENSION BRIDGE.

Discussion.*

BY J. MELAN, ESQ.

Prof. Melan. J. MELAN,† ESQ., (by letter).—The most effective and most suitable stiffening of suspension bridges—a question brought up by Mr. Lindenthal in his paper—is not only interesting in regard to the Manhattan Bridge, but is of much importance in the future development of suspension bridges. For that reason a non-American expert is glad to avail himself of the opportunity to take part in the discussion.

The question concerns two different systems of suspension bridges. One system is the stiffening truss with parallel chords, the elastic deformation of which limits the alteration in the equilibrium curve of the cable or chain under moving load; in the other system, already used by Barlow in the Lambeth Bridge, in London, but with imperfect development of details, the chain or cable itself represents the chord of a stiffening truss.

The possibility of producing with both forms of construction every required degree of stiffness, admits of no doubt, but it is equally doubtless that, assuming the same stiffness and the same unit stresses, the stiffening truss, which is separated from the chain or cable, requires more material than the other truss, particularly more than the one proposed by Mr. Lindenthal, in which the chords

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*Continued from February, 1905, *Proceedings*. See August, 1904, *Proceedings* for paper on this subject by Gustav Lindenthal, M. Am. Soc. C. E.

† Prof. Ingenieur, Lehrkanzel für Brückenbau, an der k. k. deutschen techn. Hochschule, Prag.

intersect at the supports, thereby avoiding excessively long web members. Prof. Melan.

The degree of stiffness can be judged by the deflection of a bridge under the moving load. Assuming first one half, and then the other half, of a stiffened suspension bridge, loaded with p per unit of length, then the total deffection at the quarter of the span is given by the equation:

$$y = \frac{5}{384} \frac{p}{E\,I} \left(\frac{l}{2}\right)^4 \qquad \text{.....................(1)}$$

In this equation l denotes the length of the center span, E the modulus of elasticity, and I the moment of inertia. While this formula cannot be used for a very small moment of inertia, it is theoretically exact for a constant, I, and holds also approximately true if I is variable, provided, however, that an average value of I, in each half of the span, or its value at the quarters, is substituted. Let h = height of truss at the quarter point,

F = sectional area of one chord,

$\frac{1}{60}\, p\, l$ = bending moment (approximate),

s = maximum unit stress due to the live load, p, per unit of length.

Then we have:

$$F\,h\,s = \frac{1}{60}\, p\, l^2 \qquad \text{.....................(2)}$$

Substituting in Equation 1,

$$I = \frac{F\,h^2}{2}, \text{ and } F\,h = \frac{p\,l^2}{60\,s},$$

then

$$\frac{y}{l} = \frac{600}{6144} \frac{s\,l}{E\,h} = \frac{1}{10} \frac{s\,l}{E\,h} \qquad \text{.....................(3)}$$

The proper unit live-load stress for the chords of the stiffening truss is probably 15 000 lb. per sq. in., so that $\frac{s}{E} = \frac{1}{2000}$, and, consequently, the vertical deflection is determined approximately by the equation:

$$\frac{y}{l} = \frac{1}{20000} \frac{l}{h} \qquad \text{.....................(4)}$$

For a stiffening truss, the top chord of which contains the large sectional area of a chain or cable, the above unit stress, or $\frac{s}{E}$, is rather too high than too low.

For instance, should it be required to restrict the deflections to the value of $\frac{1}{1000}\,l$ it would be necessary to make the height of the truss at the quarter point equal to one-twentieth of the span.

Prof. Melan. While it is easy to realize such a height in the Lindenthal suspension truss, it would be quite objectionable in a stiffening truss which is separated from the chain or cable, and having, as a rule, parallel chords, on account of the inadmissibly great temperature stresses in the central section, and quite apart from the general unsuitability of such high trusses.

These stresses, due to a change in temperature of 60° Fahr., are approximately:

$$s_t = 0.00085\, E\, \frac{h_0}{f} \qquad \text{(5)}$$

where h_0 signifies the height of the truss in the middle of the span and f the sag of the cable.

For $E = 30\,000\,000$,

$$s_t = 25\,500\, \frac{h_0}{f} \text{ lb. per sq. in} \qquad \text{(6)}$$

Without decreasing the stiffness of the Lindenthal truss, its depth in the central part may be assumed as small, thereby restricting the temperature stresses to sufficiently low limits. The same object can also be accomplished with a cable and stiffening truss by making the sag of the former and the depth of the latter great enough, but this would be an unsuitable arrangement on account of the increase in its cost.

In order to render these objections of no force, the advocates of the stiffening truss with cable advance two points, *viz.*:

1.—When great stiffness is a requisite, the temperature stresses in high trusses may be eliminated by a center hinge.

2.—That generally there is no necessity for great stiffness in highway suspension bridges, hence no need for high stiffening trusses.

Regarding the first assertion, it should be mentioned that Lindenthal has pointed out that the same does not hold true, and the more exact investigations* made by the writer upon this subject brought out the fact that, although the temperature stresses are in general lessened by a center hinge, they cannot be eliminated. If H = the greatest horizontal pull in the cable, ΔL its alteration in length due to the effects of temperature and live load, and if, further, F = the sectional area of the chords in the stiffening truss, and h = its depth, then the approximate temperature stress in the chords is

$$s_t = \frac{1}{16} \frac{H\, l}{F\, h\, f}\, \Delta L \qquad \text{(7)}$$

Calling g the dead load, p the live load per linear foot, L the cable length, and s_k the maximum unit stress in the cable, then

$$H = \frac{1}{8}(g + p)\frac{l^2}{f},$$

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* *Österreich. Wochenschrift f. d. öffentlichen Baudienst*, 1906. Heft 28.

Prof. Melan.

and, for a variation in temperature of 60° Fahr., we have,

$$\text{for } \Delta L = \left\{ \frac{1}{2500} + \frac{s_k}{E} \frac{p}{p+g} \right\}$$

By making $\frac{s_k}{E} = \frac{1}{625}$, Equation 7 gives, after some transformation:

$$s_k = \frac{1}{320\,000} \left(g + 5\,p \right) \frac{l^3\,L}{F\,h\,f^2} \dots\dots\dots\dots\dots\dots\dots (8)$$

This last approximate equation is quite suitable for stiff trusses, but it cannot be applied to those stiffening trusses which are weak and flexible, in which case the stresses, s_k, become materially greater and nearly as great as for the truss without a center hinge.

Granted, that by means of a center hinge a material reduction in the temperature stresses could be obtained, the writer believes that every designer will take it earnestly into consideration before he decides to build a stiffening truss with a center hinge for a larger suspension bridge. Quite apart from the fact that its up-and-down deflections are larger, the hinge itself is a weak place in the truss; it is a constructive detail subjected to forces acting unfavorably in a high degree.

It is necessary to bear in mind that the vertical shearing forces at the hinge constantly change their intensity, and that they also suddenly change in direction when the rolling load passes the hinge. This condition also applies to the wind forces, which are very considerable in long spans, and which, too, must go through the hinge and change direction. Under such circumstances, and in view of the great up-and-down deflections, a pin-connected center joint, resisting both vertical and horizontal shearing forces, presents practical difficulties which make it objectionable.

A possible substitute for such a hinge would be a flexible joint, built of plates, and partaking of the nature of a spring, a construction used by Köpcke in the stiffened suspension bridge across the River Elbe near Loschwitz (having a central span of 147 m.), but the practicability of this arrangement for great spans and forces must first be proved. It deserves to be mentioned that, disregarding the Point Bridge, in Pittsburg, the condition of which is said not to be the best, the above-mentioned Elbe Bridge is the only existing truly stiffened larger suspension bridge with a center hinge, and that even here it was found necessary to mitigate the motions of the hinge by a construction detail, gripping both halves at the meeting point, in order to obtain a kind of braking arrangement for impact.

If a center hinge in a deep stiffening truss of a great suspension bridge cannot be considered practicable, then the only recourse is a shallow, flexible truss, and therewith we give up the attainment of

Prof. Melan. greater stiffness. It has been asserted that this is admissible, at least for highway bridges, and that the realization of great stiffness in such bridges is not even economical on account of the higher cost.

It will hardly be denied that even highway suspension bridges must be stiffened, although they may have the advantage of cables with fixed supports on the towers, contributing to a more stable equilibrium; it is only in regard to the amount or degree of stiffness that opinions differ.

There can be no question that, of two bridges, designed with the same unit stresses and under the same specifications, that one is the more perfect which shows the greater stiffness. Want of stiffness goes hand in hand with a large up-and-down motion of the whole construction, and, consequently, with fatigue, deterioration of the material, and great secondary stresses at the joints.

The assertion that, by reducing the depth of the stiffening truss, its weight, and consequently its cost, can be reduced at our pleasure, needs to be put into the proper light. The value of the maximum bending moment from live load in the stiffening truss is nearly independent of the stiffness of the latter. Only in high stiffening trusses—which, however, must be left out of practical consideration on account of the high temperature stresses—would the increased bending moments in the trusses be of any consequence. The most favorable depth of stiffening truss is that which corresponds to the least amount of material in the chords. If the reduction in the depth of truss is carried too far, no saving in weight is possible without overstraining the chords.

Published investigations made by the writer upon the subject of a single span have shown that the most favorable depth of the stiffening truss is approximately obtained for

$$h = 0.8 \frac{(p + g)\, s}{p\, s_0 + (p + g)\, E\, \omega\, t}\, \frac{l}{L}\, f \ldots\ldots\ldots\ldots\ldots\ldots (9)$$

In this equation, g = the dead load and p = the live load per linear foot, s = the maximum unit stress in the chords, s = the maximum unit stress of the cable, l = the length of the span, L = the entire cable length, and f = its sag. Assuming $t = 60°$ Fahr., then we have $E\, \omega\, t = 12\,000$ lb. per sq. in., as the temperature unit stress in the chords. From these data, the most favorable depth of the stiffening truss for an East River Bridge would be about $h = \frac{1}{8} f$.

A further reduction in the depth would only result in an increase in weight. The same, of course, will occur for an increase in the depth. The economical depth, therefore, gives a shallow stiffening truss subject to very considerable up-and-down deflections.

The foregoing considerations refer only to the central span, the trusses of the side spans having been assumed as perfectly stiff or not suspended from the cable; but, owing to the flexibility of the side trusses, the bending moments and deflections in the stiffening truss of the center span will be considerably increased. Prof. Melan.

For a suspension bridge stiffened with parallel chord trusses, the results of the foregoing considerations can be summarized as follows:

1.—Effective stiffening, by means of which the deflections up and down are kept within correspondingly narrow limits, requires high stiffening trusses, which are not rational on account of the high temperature stresses. These latter cannot be entirely eliminated by means of a center hinge, which is moreover an objectionable detail and a weak place in the truss.

2.—A shallow stiffening truss with an economical amount of material admits of only an imperfect stiffness, in consequence of which the great deflections up and down, from partial loading, cause local overstraining and deterioration of the material, which is certainly not favorable to the durability of the bridge.

3.—The suspended spandrel-braced arch or truss, the top chord of which is formed by the cable or chain itself, possesses great stiffness, and, as it is subjected to only moderate temperature stresses, on account of the small height in the center of the span, it must be considered, for great bridges, as the more advantageous form of construction.

It has been claimed as a principal point that a wire cable could be used for the first-mentioned system, which is alleged to be cheaper than a nickel-steel eye-bar chain. Granted, that such is the case, a proper comparison bringing out the true economic value between the two systems can only be made on the basis of complete estimates of cost.

The difference in cost, for instance, between chain and cable for the Elizabeth Suspension Bridge, in Budapest, was only of small account, and for this reason the chain was adopted. As for the remainder, it is entirely feasible to construct the tension chords or cables of braced suspended arches, either as a wire chain, composed of wire links, as proposed by Mr. Lindenthal for a design of the Quebec Bridge (and North River Bridge), or as a continuous cable, as is shown in Kübler's prize design for a bridge across the Rhine at Bonn. The difficulties of the panel-point construction of such cable trusses, therefore, can be solved readily, in most cases, by proper studies and experiments.

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THE WATER-WORKS OF PORTERVILLE, CALIFORNIA.

Discussion.*

By Messrs. D. C. Henny, H. F. Dunham, G. W. Tillson and William Mayo Venable.

Mr. Henny. D. C. Henny, M. Am. Soc. C. E. (by letter).—The writer has read this paper with great interest, and is impressed with the difficulties which frequently confront an engineer when called upon to design and build small works. Conscientious solution involves the same careful consideration and study as is required for works of great magnitude, yet, if preliminary investigations and tests of material used in construction were carried to the same extent, the engineering expense would reach an objectionably high ratio of total cost.

The author's experience with a portion of the cement used in his works indicates the chances which an engineer in such case is forced to take, and indeed is warranted in taking.

Gasoline Engine vs. Induction Motor.—The reasons advanced for the selection of gasoline engines for operating the pumps at Porterville appear to have been purely financial, and it is stated that an estimated annual saving of $700 has probably been effected.

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*This discussion (of the paper by Philip E. Harroun, M. Am. Soc. C. E., printed in *Proceedings* for January, 1905), is printed in *Proceedings* in order that the views expressed may be brought before all members of the Society for further discussion.

Communications on this subject received prior to April 22d, 1905, will be published subsequently.

The writer would infer from this that conditions at Porterville are quite abnormal. Reducing the author's figures of cost of pumping during June, 1904, presented in Table 17, to the net horse-power unit, they stand as follows: Mr. Henny.

	Cost per net horse-power hour.
Fuel	0.89 cent.
Supplies	0.35 "
Attendance	1.90 "
Total	3.14 cents.

It will be noted at once that the cost of attendance is high, as is generally unavoidable with small, gasoline-driven plants. Moreover, this item is not subject to much reduction in future, as the plant appears to have been working close to its full capacity for the time actually run.

The great advantage of electric drive, for small plants, lies in the fact that practically no attendance is required. The writer visited Porterville some years ago, and incidentally inspected the old motor-driven centrifugal pumping plant which was at the time running without attendance, and he was then informed that the pump ran practically all the time and required no attention beyond starting and stopping and the occasional filling of the oil reservoirs.

In a system of water-works in California, with which the writer has been connected for several years, three gasoline pumping plants of 15, 25 and 36 h. p., respectively, have been in use, for which the cost of attendance per net horse-power hour ranged from 1.25 to 3.00 cents, according to conditions and sizes of plant. The same system also contains a 15-h-p. motor-driven pump which has now been in use about two years, and, in regard to which, the superintendent reports that cost of attendance is so small as to be negligible, as the pipeman throws the current on and off when he leaves and returns to the adjacent stable.

For purposes of comparison, the writer submits the following estimate of cost of pumping by electric power under the usual conditions in California on a basis of cost of current at the rate of $100 per horse power per year for current actually used, as per meter measurement, assuming 60% efficiency for the motor and pump.

	Cost per net horse-power hour.	
Power	1.92 cents.	
Supplies	0.10 "	
Attendance	0.53 "	(variable)
Total	2.55 cents.	

Mr. Henny. For the same amount of work as was done in Porterville during June, the foregoing estimated cost of attendance would amount to $50 per month, which is high.

In first cost, an induction motor is also more economical than a gasoline engine, and, furthermore, it is compact and requires less foundation and housing. Thus, the fixed charges will be relatively smaller, and, likewise, it will show a less depreciation, owing to its simplicity and freedom from wear.

While the conditions in Porterville may have fully justified the selection of gasoline engines, in the majority of cases where electric current is available, at reasonable rates, it is believed that the latter will give better financial results in small plants.

Spiral-Wound Stave-Pipe.—The author's comments regarding the failure of pipe of this class at Porterville are of interest, in view of its growing use, factories having sprung up at half a dozen points throughout the West. The writer manufactured some of this pipe, 4 and 6 in. in diameter, more than 10 years ago, to be used in places where it would be free from serious fluctuation of pressure. The wire was No. 12, galvanized, the pressure was light and the factor of safety of the wire was from 5 to 6. In order to secure a proper bearing of the wire upon the wood, the diameter of the wire must either be small, or the weight of metal must be made excessive, otherwise there is danger from indentation and consequent leakage, especially where fluctuations of pressure occur.

The writer realized that small wire, no matter how well galvanized or coated, cannot be expected to have a long life when in contact with alkali soil, and for this reason he abandoned the manufacture of pipe of this class long ago, although that manufactured at the time is believed to be still in use.

As now manufactured, this pipe is wound with $\frac{1}{4}$, $\frac{5}{16}$ and $\frac{3}{8}$-in. wire for sizes less than 12 in. The spacing of the windings seems to be determined generally for the strength of steel alone, the danger from indentation being entirely ignored. The results at Porterville, as recorded by the author, may be considered a confirmation of formulas established long ago.

Mr. Dunham. H. F. DUNHAM, M. AM. SOC. C. E.—The Society should be grateful for this paper, although its very excellence may be the cause of trouble for some of our members. The author's work was well carried out, then well written out, and now it has been well read out, made real and so like actual experience that every member accustomed to water-works construction may find himself unconsciously including Porterville in his own list of completed plants.

A President of the Technical Society of the Pacific Coast is somewhere quoted to the effect that engineers should conceal their mistakes; but the builder of this water-works speaks from a slightly different position, on the Slope, for he tells all that he has done. Mr. Dunham. No one can ask for more. His work does not show the usual number of errors, if indeed there were any errors. There can never be enough such papers.

Members who have seen a 3-in. shaft neatly welded in an old army forge, and who believe that in nearly every community there is latent mechanical talent, may wonder why the author did not bring to the work a small engine lathe, an 8-in. pipe threader and a portable forge, wherewith to avoid delays, earn more than the cost of the machines, and afford comfort to those who have idle hours when operating the works. But this is too small a matter for review; so also was the application of oil to troubled waters.

Because of the fact that every plant must be designed to meet local conditions, and, further, because the speaker has no knowledge of those conditions, it is evident that any discussion of the general plan must be in the nature of an inquiry, and cannot be regarded as criticism.

It is always interesting and generally desirable to have on record a good sanitary and quantitative analysis of the water to be supplied to a city. It is helpful in many ways. The effect of the water upon pipes may be predicted, to some extent; also its effect upon paint; and it is possible that such analysis might show that no paint would ever be required inside a metal stand-pipe or tank. Then the effect of light upon the water is disclosed by an analysis, and, if necessary, extra care can be taken to cover the stand-pipe or reservoir.

The question of supply, where well water is used, must always be important. Wells are frequently located at considerable distances from each other, and, when they are quite near, it is worth while to note why they are not separated, and how much more water can be obtained from two than from one. The method of perforating well pipes after they are in position is not common in the East, and is not well understood by the speaker. An important object in such work is to exclude sand or silt at the maximum draft of water. A Cook strainer is sometimes effective. Is the pipe perforated in place effective?

It is a good feature in any design to introduce as few parts as possible, if they will give the required service. Evidently, it was deemed necessary at Porterville to have an elevated tank of 75 000 gal. capacity and to store about 100 000 gal. for protection against fires. The cost of the elevated tank and its foundations would not have been greatly exceeded by the cost of a plain stand-pipe, of about the some height and diameter, and its foundations; and such a stand-pipe, connected with by-pass and pressure valve to the pumps, would give a storage capacity more than twice as great as

Mr. Dunham. the ground reservoir affords. Or, if the designer had recalled the fact, set forth by Professor Pence, that something unexpected has happened to about 25% of all the stand-pipe or tank structures in the country, and decided to pump direct and use the available funds for the storage of water for fire protection, and possibly for a third pump, a much larger quantity could have been stored and more permanent work secured, with, perhaps, greater safety when fires occur, and no greater expense for operation, since the quantity of water now demanded by consumers must make constant attendance at the station necessary. In fact, such a station, upon which fire protection depends, should never be left without a competent, wide-awake engineer. The speaker has designed and built covered reservoirs of the same inside diameter, 50 ft., but much deeper, doming them over with masonry, without any central or inside support, and covering them with earth. The cost of such permanent work, with a concave bottom to resist upward pressure if the reservoir is quickly emptied, may be said to decrease per 1 000 gal. of water stored with the increase in the size of the reservoir. It may be pertinent to inquire why the Porterville design included a depressed reservoir and an elevated reservoir. A by-pass between them, not mentioned in the description, would enhance the present value of both when the tank is not used for fire protection.

The Porterville map shows the water-works located apparently in the center of the town or city, where presently there may be from 6 000 to 8 000 inhabitants. No contours are shown, and if there were it is doubtful whether they could offer a fair explanation. No reason is given for making that location or for continuing it. Almost every State Board of Health Report carries pages of caution against such locations, for it is always recorded that reasons existed for making an analysis of the cistern water, that too much chlorine was found, that afterward a crack in the cement wall was discovered, and, lastly, that polluted ground-water from somewhere found its way in when the water was low in the cistern. A repetition of all this on a larger scale is apparently invited in Porterville. Adobe soil may have unfamiliar qualities, but oil permeates it. On a flat surface, 4 in. of concrete may be water-tight, but it cannot be expected to resist the upward pressure of a head of even a few inches, if rainfall in that country ever gives such a head when the water is suddenly lowered in the reservoir. The wells may take water at a depth of hundreds of feet, but well pipes are not always new, and new pipes are not always perfect.

Doubtless there are reasons for the design, and it must not be assumed that those reasons are associated in any way with the fact that the greatest sum a city can raise for improvements is too often the least sum which can be found in an engineer's estimate.

Mr. Dunham.

The personal equation in such work, particularly in small undertakings, is so important that it dwarfs nearly everything else. One may have almost any number of excellent tests from cement, and from a good quality of cement, sand, gravel and broken stone, but if one fails to secure good foremen there may be very bad work. This has no relation to anything in the paper. It is a relation of experience when the work is not of such magnitude as to warrant ideal conditions. A good foreman should not be under iron-clad rules in such cases. He should use his judgment, reject poor material, make changes in the specified proportions when necessary, and always work to get good and permanent results. In the filtration of water it is expected that workmen will soon be able to determine at a glance whether the effluent contains too many bacteria. It is not unreasonable to expect a foreman to determine whether there is virtue in cement when he is interested in the question and when his work is one continuous decision upon that question.

Mr. Tillson.

G. W. Tillson, M. Am. Soc. C. E.—This paper is worthy of special commendation, because it gives, not only the method, but the cost, of construction, in regard to labor and the quantities of material required. While descriptions of methods of construction of many and large works are common, it is difficult to obtain their cost. That, of course, is perfectly natural, because nearly all are built by contract and the contractors keep to themselves the actual cost of the work. Therefore, when a paper gives in detail, as this does, the quantities of work and material used, it should receive special mention.

The author's allusion to the morning when it was possible to draw oil from the water taps calls to mind an occurrence which came under the speaker's observation in Omaha, some years ago, when a gentleman one night went into his parlor to light his gas. When he turned on what he supposed was the gas, he found nothing but water. Although this was rather surprising, it was easily explained, as most things of that kind are when all the facts are known. In a nearby street the 20-in. water main, under quite a heavy pressure, burst, and, as it burst, threw up the earth, and broke the gas main, consequently, the water flowed into the gas main and filled that and also the service pipes, so that when the jet was turned on the gas and water escaped.

In reading the technical part of the paper the speaker's attention was called to the cement and the resulting disintegration of the concrete. The difficulties which an engineer meets in carrying on a work of that kind, where he must take some small chances, are fully appreciated, and yet it would seem that this is a good time to emphasize the necessity of making tests of cement for such work, and also state how those tests should be made. Neat cement tests

Mr. Tillson. are of no particular value, unless something is known about the particular brand of cement that is being tested. In order to understand the cement, fully continued tests, both neat and with sand, must be made, so that an approximate ratio can be established between the neat and the sand tests, because any tests of cement without other information are of value only as the conditions which surround the tests conform to the conditions which surround the material as it is actually in the work. Now, cement when used is mixed with sand, so that it is absolutely necessary to establish this ratio without a thorough knowledge of the brand of cement to be used. From the tests given by the author he certainly would be justified in expecting good results in his concrete, as they compare very favorably with the tests of first-class cements used in the vicinity of New York City. The paper does not state that the actual cement used in the work was tested, but that, previous to buying the cement, the brand was tested, and, as there were no facilities for testing the cement while the work was going on, chances had to be taken. It is very difficult to understand why the concrete should have acted as it did. It will be noticed that, although all the concrete that failed or disintegrated was below the water line, all the concrete that was below the water line did not fail or disintegrate. There are some cements, which, if allowed to set dry, will give good results, but if used in water immediately after mixing will disintegrate, but it seems strange that concrete should last eight weeks, and set normally up to that time, and then disintegrate.

A case that came under the speaker's notice a number of years ago showed the necessity of testing cement while it was being used. In a town in the South, on the Mississippi River, in the construction of a sewerage system, it was necessary to build a structure across a bayou which backed up from the Mississippi. One of the division engineers was put in charge of the work and told by the consulting engineer that he would be back in a month, and that at that time he expected to see the structure completed. The engineer went to work promptly, constructed his coffer-dam of the most approved form, and pumped it out. By the time the water was pumped out the bayou was dry, and there was no need of a coffer-dam. He proceeded, however, to construct the piers, of brick and cement. After he had them constructed he decided that the cement was bad, and pulled the piers down. He explained that the cement passed the pat tests, and that he did not see what was the matter. By the time the piers were torn down the month had expired, and the consulting engineer had returned and found the conditions exactly as he had left them, except that the engineer had a four weeks' pay roll to be accounted for.

Mr. Venable.

WILLIAM MAYO VENABLE, ASSOC. M. AM. SOC. C. E.—The speaker would like to know of any places where oil has been stored successfully in concrete tanks. He has been asked about such cases several times, but has not been able to answer the inquiry. Explicit data regarding the imperviousness of well-made concrete to oils of various densities would be very interesting.

Vol. XXXI. MARCH, 1905. No. 3.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PAPERS AND DISCUSSIONS.

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MAXIMUM RATES OF RAINFALL AT BOSTON.

Discussion.*

By Messrs. C. E. Gregory, Asa E. Phillips, E. Kuichling, L. J. Le Conte, William Mayo Venable and C. S. Burns.

Mr. Gregory. **C. E. Gregory, Assoc. M. Am. Soc. C. E.**—In comparing the valuable data given in this paper with data already at hand, it occurred to the speaker that, by using one of the expressions for intensity, a more rational and general formula than those in general use might be deduced to show the relation of rainfall to run-off; one that would not only simplify this problem of the relation of run-off to rainfall, but also take into account the shape of the water-shed and possibly serve as a basis for harmonizing, somewhat, the conflicting data.

First assume that, for all water-sheds of equal area and of similar shape, character and slope, there should be a fairly constant ratio between rainfall and run-off for storms of equal duration and intensity. In practice, however, all water-sheds and all storms are different. Therefore, each different storm and water-shed must be reduced to a common basis of comparison.

The qualifying factor, in any water-shed, which cannot be expressed by a direct coefficient, is the time it takes the rain, falling on the roofs and streets in the most distant part of the water-shed, to reach the point under consideration.

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* Continued from February, 1905, *Proceedings*. See December, 1904, *Proceedings* for paper on this subject by Charles W. Sherman, M. Am. Soc. C. E.

The qualifying factors in the storm are its duration and intensity. **Mr. Gregory.**

All storms, however, may be reduced to a basis of comparison on a particular water-shed by comparing the greatest average intensity for the time the water takes to travel to the point in question, rather than the maximum intensity for a shorter time, or the average for the entire storm. Storms compared on this basis show a remarkably constant relation to the maximum run-off, while, if compared in other ways, they show great variation. Unfortunately, the speaker, as yet, has been able to obtain but very few data which are in proper form to make this comparison, and has been confined, almost entirely, to data taken from a report by Rudolph Hering, M. Am. Soc. C. E., on gaugings taken in 1888 in the Sixth Avenue Sewer, in New York City. These have shown a ratio of from 50 to 60% of the average intensity for the proper time for the maximum rate of run-off.

The relation of intensity of storms to their duration is most simply expressed by Professor Talbot's "Ordinary" form of curve, $i = \frac{105}{t + 15}$.

To find the proper intensity for any water-shed, substitute for t, $\frac{l}{v}$, in which l is the greatest length of the water-shed, and v is the average velocity; then, calling inches per hour equivalent to cubic feet per second per acre, $Q = A\ C\ i$, in which Q = cubic feet per second, A = acres, and C is the coefficient of the relation of run-off to rainfall, and will vary with the nature of the surface and the drainage system; then, for i, substitute its value and allow 10 minutes for the water to reach the sewer from the roofs and streets, and result is

$$Q = A\ C \frac{105}{\frac{1}{v} + 15 + 10} \qquad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

To make the formula general, express v in terms of A and S, S being the average slope of the water-shed, in feet per thousand. To do this it is necessary to substitute in the standard formulas for velocity, $v = C \sqrt{R S}$. Giving to C an average value of 120, and expressing S in feet per thousand, the result is

$$v = 120 \sqrt{R \times \frac{S}{1\,000}}$$

$$\text{and } v^2 = 14.400\ R\ S,$$

$$\text{or } v = 3.8 \sqrt{R\ S}.$$

Also, $Q = A\ v$, and $v = \frac{Q}{A}$

If A = area $= \frac{\pi d^2}{4}$, and $R = \frac{d}{4}$, assign an average value for

Mr. Gregory. $\sqrt{R}$, say $\frac{1}{2}\sqrt{R}$ or $\sqrt{\frac{R}{4}}$, then the average value, expressed in terms of d, is $\frac{d}{16}$, or $d = 16\,R$. Substitute for d its value, and $A = 192\,R^2$; then substitute for A its value, and $v = \frac{Q}{192\,R^2}$,

$$\text{but } v = 3.8\sqrt{R\,S},$$

$$\text{therefore } 3.8\sqrt{R\,S} = \frac{Q}{122\,R^2}.$$

$$\text{and} \qquad R^{\frac{5}{2}} = \frac{Q}{730\sqrt{S}}$$

$$\text{or} \qquad R^{\frac{1}{2}} = \sqrt[5]{\frac{Q}{730\sqrt{S}}}$$

$$= \frac{1}{3.74}\sqrt[5]{\frac{Q}{\sqrt{S}}}.$$

Substitute for $\sqrt{R}$ its value, and

$$v = \frac{3.8}{3.74}\sqrt[5]{\frac{Q}{\sqrt{S}}} \times \sqrt{S}$$

$$= \sqrt[5]{Q\,S^2}$$

very nearly.

Then, as A is an average value for Q, it is sufficiently accurate to substitute it for Q, thus

$$Q = A\,C\,\frac{105}{\dfrac{l}{60\sqrt[5]{A\,S^2}} + 25} \quad \ldots\ldots\ldots\ldots(2)$$

as the general form for the relation of run-off to rainfall, and this can be compared directly with any rainfall data which may be desirable.

This formula gives for average-shaped water-sheds values somewhat similar to McMath's when 0.80 is used for C and 2.75 for r, but smaller results for very long narrow water-sheds and larger ones for those which are fan-shaped.

If great accuracy is desired, the value of the term, $\frac{l}{\sqrt[5]{A\,S^2}}$, may be tested, after the sizes and velocities have been worked out, by taking the actual velocities and using Formula 1, and, if desirable, the time allowed for the rain to reach the sewers may be changed.

It should be noted that the area tributary to the Sixth Avenue Sewer gauged by Mr. Hering consisted of 43.5% roof area, 46.5% paved area and 10% grass area.

Mr. Phillips.

Asa E. Phillips, M. Am. Soc. C. E. (by letter).—The following is submitted as a local contribution to the general subject of maximum rates of rainfall:

1.—Comparative diagrams of certain exceptional storms, 1890-1904, as recorded at three stations in Washington, D. C. (Figs. 2, 3, 4, 5, 6 and 7);

2.—Rate diagrams of several important storms (Plate XXVII; also, rate points of local storms not otherwise shown; the 2-in. rate curve, and the Weather Bureau curve of maximum intensity, 1881-96 (Henry).

These records were obtained at gauges located as follows:

Gauge 1, at Twenty-fourth and M Streets;
Gauge 2, at Thirteenth and K Streets;
Gauge 3, at First and C Streets.

The distance between Gauges 1 and 2 is 2 100 yd., and between Gauges 2 and 3, 1 975 yd. The line of these gauges parallels the general river valley quite closely. The usual approach of intense storms is from the northwest, striking the gauges in their alignment and in their order as numbered. The gauges of the Engineer Department of the District of Columbia, designated as Gauges 2 and 3, were designed by Desmond Fitz Gerald, Past-President, Am. Soc. C. E., and are regularly inspected and very well maintained. The records plotted as of Gauge 1 refer to the gauge of the United States Weather Bureau, and are thus designated for convenience. They were obtained from the published records of the Bureau. Where single station records are plotted, the number of the gauge is indicated.

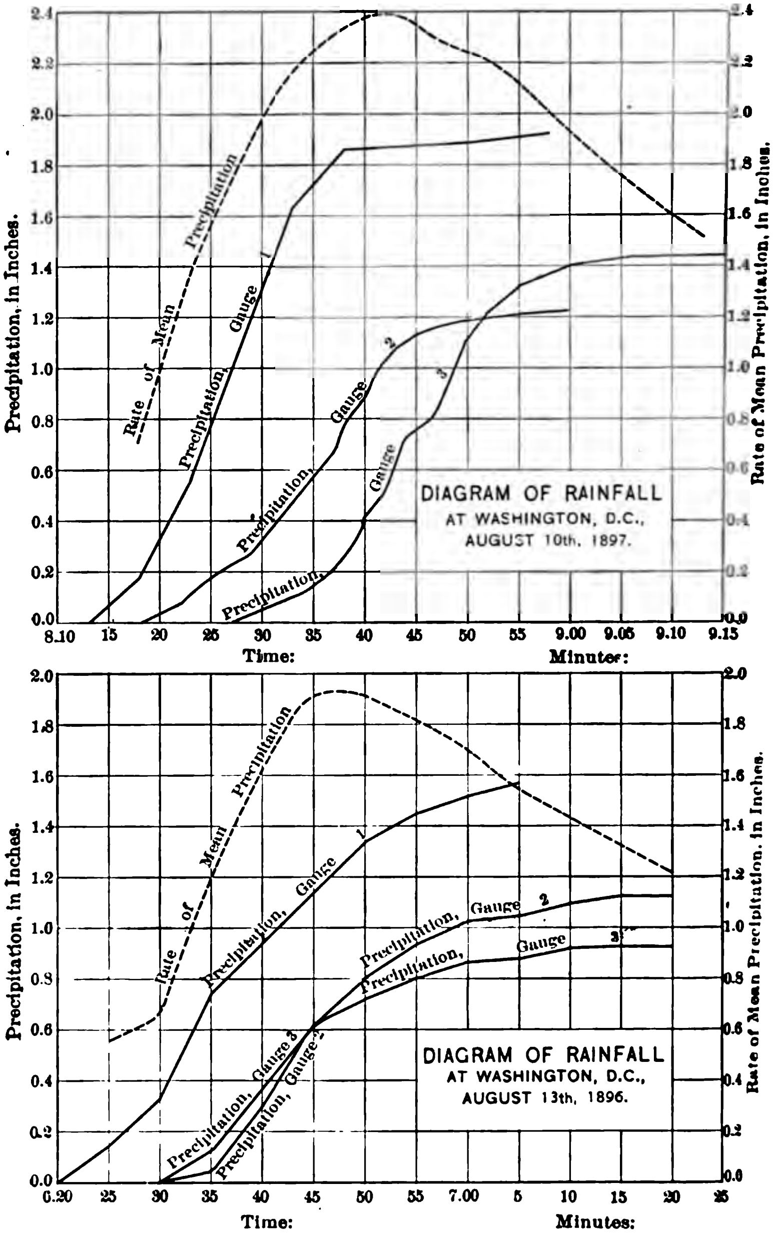
The data here presented are in part abstracted from a report (not heretofore published) by the writer, in 1900, on certain drainage works for the City of Washington.

This is not, perhaps, the first attempt to compare the records of a series of rain gauges covering a considerable area, and the results are altogether incomplete and tentative, yet this phase of the subject appears to merit discussion, and more extended observations may lead to a better understanding of several of the factors of run-off.

The feature of these comparative records, the writer would suggest, is not illustrated clearly by the curves of mean rate shown on the diagrams; for, in the latter, the variation in station rate is an important factor; but, rather, the very limited area of maximum precipitation, which is well indicated by the travel of the maximum across the field of observation.

Whether the great storms of 1898 at Philadelphia and Norfolk (Fig. 5), which were of extraordinary duration, were recorded correctly by the single station of observation, or whether the average rate for any period, over a considerable area, fell far below that

Mr. Phillips.



FIGS. 2 AND 3.

Mr. Phillips.

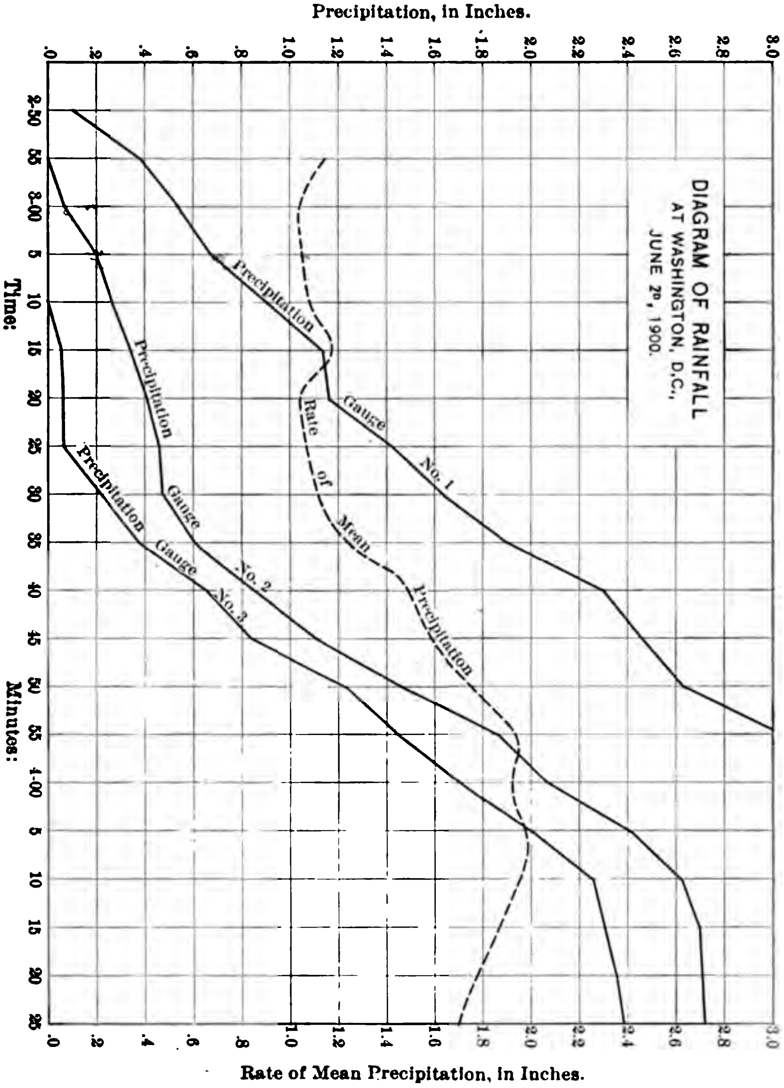


Fig. 4.

Mr. Phillips.

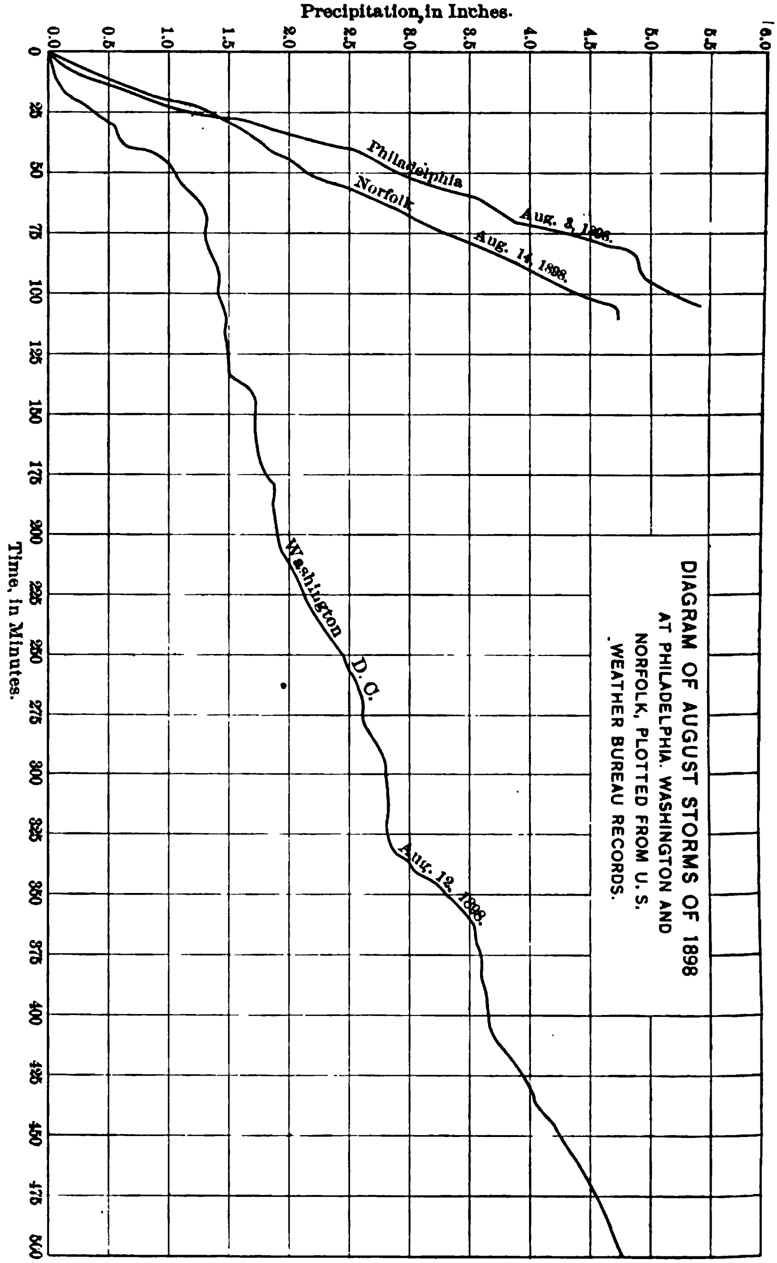


FIG. 5.

Mr. Phillips.

TIME INTERVAL BETWEEN MAXIMUM RATES OF PRECIPITATION
AS RECORDED AT EACH STATION, FOR EXCESSIVE STORMS,
AT WASHINGTON, D.C., 1890 TO 1904.

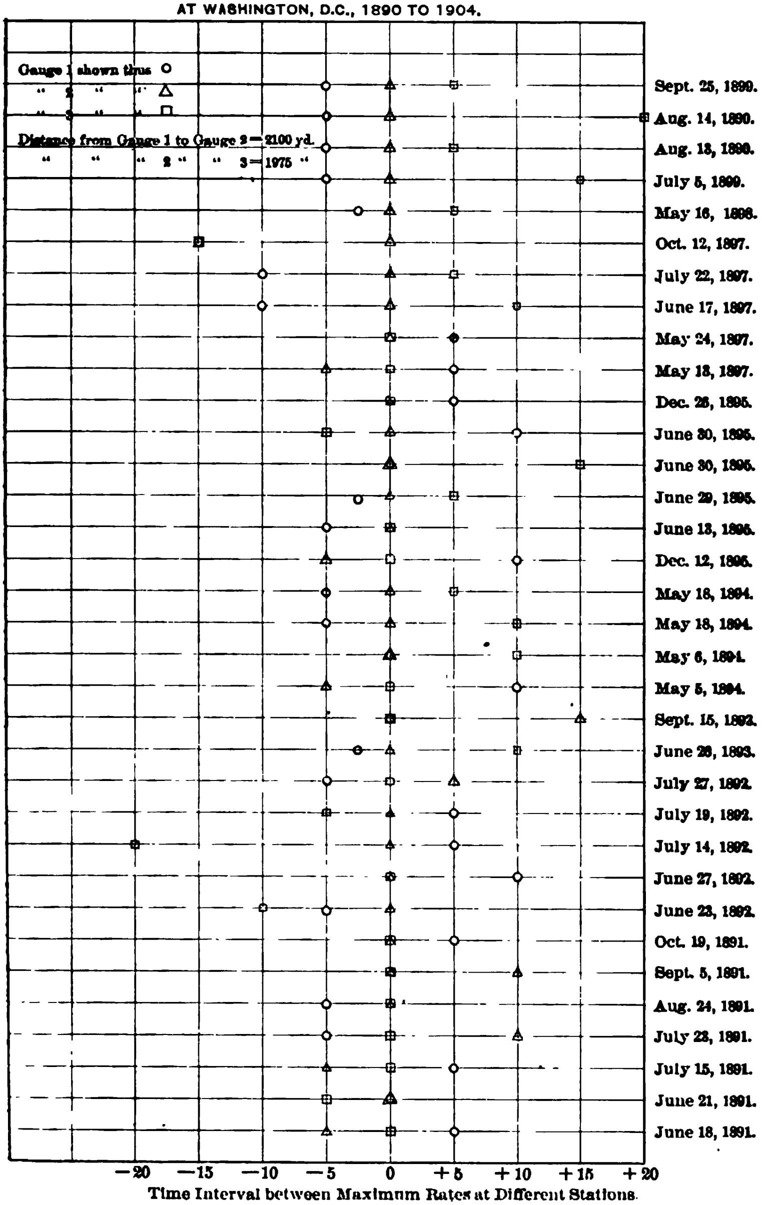


FIG. 6.

Mr. Phillips.

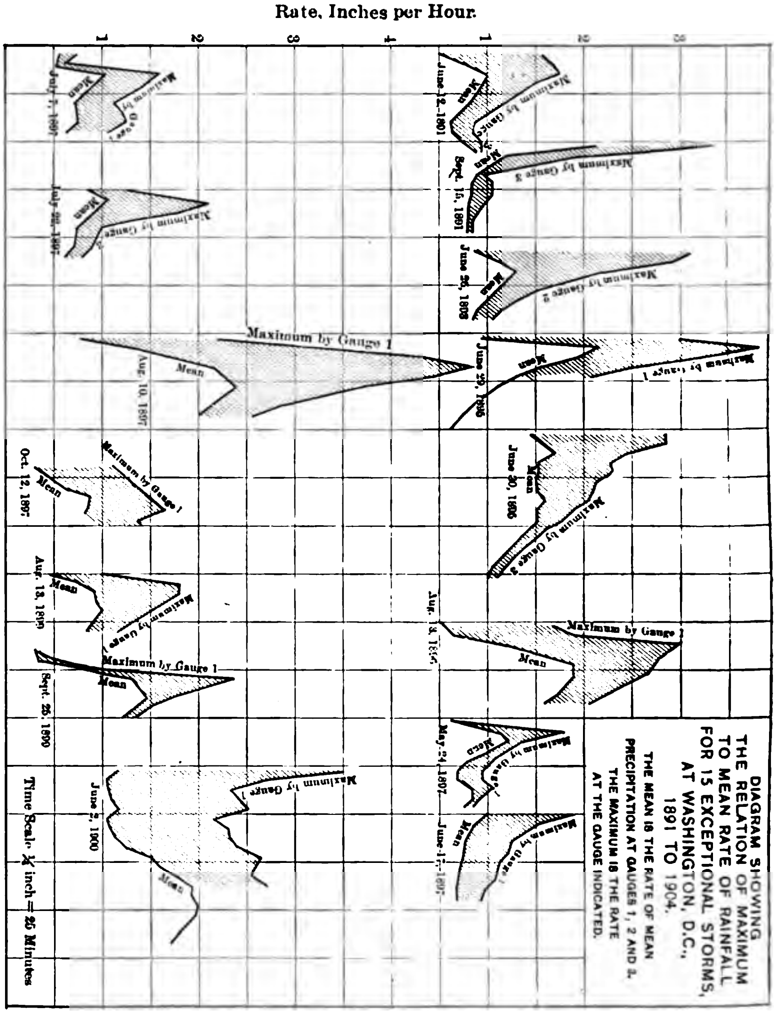
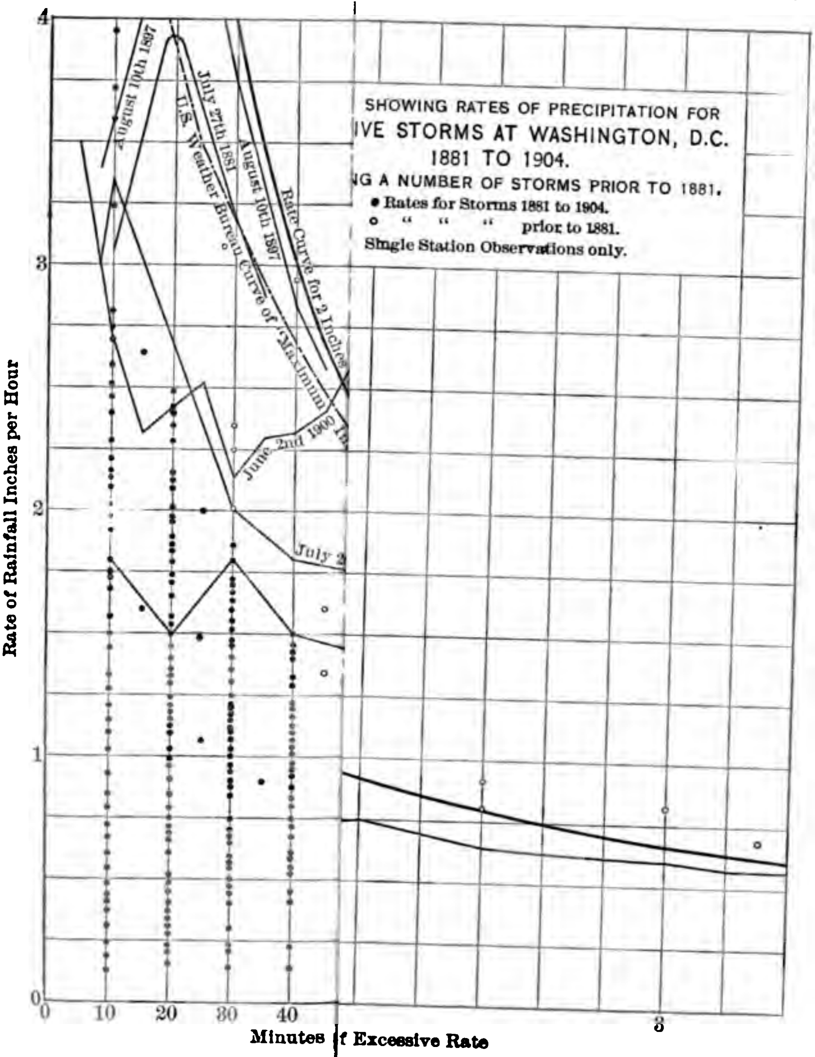


FIG. 7.

PLATE XXVII.
PAPERS, AM. SOC. C. E.
MARCH, 1905.
PHILLIPSON RAINFALL.



record, it is not possible to determine. Local observations, however, seem to indicate that no storm has here been recorded having an average precipitation for the three stations exceeding 2 in. of actual rainfall in one hour, and no storm of great duration—and therefore considerable area, as city areas are measured—having an average which approached 2 in. in any one hour. Mr. Phillips.

Mr. Kuichling. E. KUICHLING, M. AM. SOC. C. E.—This paper is a very valuable contribution to meteorology, and the author deserves great credit for his work. There is a point involved, however, which should be stated more clearly or definitely. This pertains to the meaning which is given to the term "intensity of downpour." It can be presumed, from the data submitted in Table 1, that the intensities recorded were uniform, or very nearly so, during the corresponding durations in minutes; but when the numerous long durations are observed, a doubt as to the correctness of such presumption arises in the minds of those who have studied closely the behavior of heavy precipitations, as it is rarely the case that the intensity is practically uniform for more than one hour.

To make the point under consideration somewhat clearer, take the case of the three heavy showers, each lasting from 20 to 30 minutes, and following each other in the course of 6 hours with a light rainfall or drizzle in the two intervals. The total precipitation may be 3.0 in., and the average 0.5 in. per hour, but this is very different from the uniform maximum, which may have been 2.0 in. per hour for three periods of 15 minutes each. On one occasion, while in a mountainous district, the speaker observed five such alternating heavy showers and drizzles in a single afternoon. Rains of this description are often reported as being continuous, from which it may be inferred that they were also of uniform intensity throughout the stated period of time, thus leading to an erroneous conclusion.

A comparison of the three rainfall diagrams given in Fig. 1 with the corresponding numerical data given in Table 1, shows that on July 21st, 1894, the recorded intensity of 2.94 in. per hour during 22 minutes was practically uniform; that on August 22d, 1899, the recorded intensity of 4.62 in. per hour during 22 minutes was likewise nearly uniform, whereas the record of 1.65 in. per hour during 85 minutes on the same day is not for uniform intensity, but is the average rate for two distinct, heavy showers with an interval of about ½ hour of drizzle; and lastly, that on September 20th, 1899, the recorded intensity of 1.07 in. per hour during 130 minutes was nearly uniform, while the record of 0.44 in. per hour during 460 minutes on the same day represents the average rate for the whole period, which includes about 6 hours of light rain and drizzle. As these three diagrams are given as samples, it may be

Mr. Kuichling. inferred that the remaining records were treated in like manner by the author, and hence that all the data in Table 1 do not refer to uniform intensities.

The conclusions reached from studies of the intensity of rainfall are usually applied in computing or estimating the maximum run-off from drainage basins of known area, and in many cases it becomes of great importance to determine such maximum without much room for error. This is particularly the case in the storm-water drainage of urban districts of moderate size, and as a large percentage of the precipitation usually finds its way quickly into the various tributary sewers or other drainage channels, it is necessary to know the probable maximum intensity of the rainfall for different periods of time. From the nature of the problem, however, a rational estimate of the proportion of the rainfall which flows off on the surface cannot be made unless the precipitation takes place at a uniform intensity on all parts of the water-shed; and hence, to be of good service, all compilations of maximum rainfall should be made with particular reference to uniform intensity during the period of observation.

The lack of such tabulations has led to many serious underestimates of the run-off in urban districts, and also to the establishment of many different formulas for computing the probable maximum flood discharge from river basins of greater or less magnitude. Usually, such formulas are made by platting as ordinates the greatest observed flood discharge, in cubic feet per second, from various catchment basins of similar topographical and geological character, but of different area, and the magnitudes of the basins in acres or square miles as abscissas; a curve is then drawn through or near the highest points in the diagram thus obtained, and, finally, the equation of such curve is sought in order to express the relation between maximum discharge and area. Further study of the data leads to the introduction of an assumed average rainfall intensity and the corresponding modification of the empirical constants of the original formulas, so as to make the expression applicable to some of the cases where the rainfall was known with more certainty.

The next step in the evolution of a flood discharge formula is to recognize in the expression the time needed for the surface drainage water to flow from the most distant parts of the catchment basin to the point of observation on the stream. This if often done by introducing the average slope or grade of the surface, as well as the average length and width of the territory. Here, again, trouble is encountered, owing to the perverseness of many of the data in refusing to fit the formula so laboriously devised; and in the hope of finding relief from the complication, the territory is then subdivided into two or three classes, such as mountainous, hilly and flat, the

Mr. Kuichling.

area of each class being introduced with a different coefficient or exponent and also with corresponding different average grades. The results, hitherto, however, have not been found wholly satisfactory, and when a fairly close agreement with a correct actual observation of flood discharge is encountered, such agreement may be attributed more to accident than to strict conformity with all the various factors involved. This is necessarily the case where a number of average values must be used.

In drainage work the principal elements to be considered are the intensity and duration of the precipitation, the extent and character of the surface upon which the water falls with respect to absorption and evaporation, and the time which elapses before the run-off from the most distant points of the area reaches the point of observation. It is obvious that, when the rain continues sufficiently long at uniform intensity, the run-off from a given area will be the maximum corresponding to that particular intensity when all portions of the area are contributing to the flow at the same time. From every catchment basin, accordingly, there is a separate maximum run-off for every different uniform intensity of rainfall, and, in finding the absolute maximum, the only question is whether the higher intensities are of sufficient duration to allow water from all parts of the basin to reach the point of observation at the same time.

In the case of a large and uniformly constituted territory, it may happen that the absolute maximum run-off will occur at the end of a long rainfall of moderate uniform intensity. The reason for this fact is that in storms of short duration and high intensity, the flow from the lower portions of the area reaches the collecting stream and pass the point of observation before the flow from the upper portions reaches that point. It may also happen that, in a large but diversely constituted territory, the run-off will become greatest for a rainfall of high intensity and relatively short duration. This is due to the greater run-off from the less absorptive portion of the area than from the more absorptive remainder. On the other hand, the greatest run-off from a small area always occurs toward the end of a rainfall of high intensity. Drainage areas of the same general character in municipalities, therefore, may be classified according to the length of time taken for the surface water from the most distant parts of the district to reach the given point in the sewer or other watercourse. Thus there may be a 10-minute district, a 15-minute district, etc., from each of which the absolute maximum run-off will be governed mainly by its area and the corresponding uniform maximum intensity of the rainfall. Therefore, it is of the utmost importance to know the relation between this latter factor and its duration, and from the foregoing

Mr. Kuichling. considerations it is plain that average intensities can be of no particular value in drainage computations.

From several recent compilations of heavy rainfalls of uniform intensity, relating to localities in the vicinity of the city of New York, the speaker adopted the expression (using the authors notation):

$$i = \frac{120}{t + 20}$$

to represent the relation between the duration, t, in minutes, and the "ordinary" uniform maximum intensity, i, in inches per hour. If it were desired to construct a run-off formula with this expression as a factor, the process would be as follows: Let A = area, in acres; and m = run-off factor, or proportion of the rainfall which runs off from the surface at the time of maximum flow. This factor is generally the same as the proportion of impervious surface on the entire area, A. As the intensity, i, also represents very nearly the same number of cubic feet per acre per second, we would then have, if Q denotes the "ordinary" absolute maximum run-off, in cubic feet per second, from the area:

$$A : Q = m\,A\,i = m\,A\,\frac{120}{t + 20}.$$

As a matter of fact, however, the water which falls on a more or less irregular surface does not begin to flow off immediately, but accumulates thereon until the depressions are filled and the primary rapid absorption and evaporation have ceased. It then commences to run off slowly in a film or sheet of gradually increasing thickness until it reaches some kind of channel wherein it can flow more rapidly, and eventually it finds its way into some larger channel which conveys it quickly to the sewer or principal watercourse. Observation demonstrates that even in the heaviest showers several minutes elapse after the rain begins, before the water appears in appreciable quantity in the sewers or other collectors, and hence it is proper to increase t correspondingly in the foregoing expression. Usually, this is done by adding to t from 5 to 10 minutes, depending on the character or development of the given area, A. In general, therefore, the expression for Q can be put in the form:

$$Q = m\,A\,\frac{a}{t + b}.$$

If the area has the same character throughout, the factor, m, will be constant, but if the character changes in different portions, m will become variable as the area, A, increases. In municipal sewerage work, the factor, t, represents the number of minutes required for the passage of the water through the longest line of sewers in the district, when the same are full or nearly so; and as

Mr. Kuichling.

sizes, grades and velocities usually vary in considerable degree at different localities in the same area, the successive increments of t may correspond to widely different increments of A, so that, in algebraic terms, A becomes a more or less complex function of t. For example, if two plane surfaces slope toward each other, so as to cause the velocity of the water which flows over the surface in a direction at right angles to the intersection of the planes to be equal to the velocity in the gutter formed by such intersection, the relation of A to t will be expressed by

$$A = n\,t\,(t + c).$$

Under other conditions we may have

$$A = n\,t^2,$$

$$\text{or } A = \sqrt{n\,t + p^2} - p,$$

$$\text{or } A = n\,t^2\,(1 - c\,t), \text{ etc.},$$

depending on the peculiarities of the territory under consideration, and applicable only within certain limiting values of t.

Of these latter expressions, the first gives a curve which is convex to the axis of t; the second gives one which is concave to said axis; and the third gives one which is at first convex and afterward concave to said axis, but subsequently intersecting it at a distance $t = \frac{1}{c}$, so that A becomes a maximum for $t = \frac{2}{3c}$, whence the expression can obviously be valid only between the limits, $t = 0$ and $t = \frac{2}{3c}$. Furthermore, in both the first and the second expression, A never reaches a maximum for a finite value of t, and hence these forms can apply only to portions of basins of great magnitude. It is probable, therefore, that the third form is better adapted for use in a general formula relating to areas of moderate size, but the expression of t in terms of A then becomes very complicated, as it is the root of a cubic equation. For the sake of simplicity in further investigation, however, the value of Q in this case may be expressed in terms of t, thus obtaining:

$$Q = m\,a\,\frac{n\,t^2\,(1 - c\,t)}{t + b} = m\,n\,a\,\frac{t^2\,(1 - c\,t)}{t + b}.$$

In this general formula, Q becomes a maximum for

$$t = t_1 = \frac{1 - 3\,b\,c}{4\,c}\left[1 + \sqrt{1 + \frac{b}{c}\left(\frac{4\,c}{1 - 3\,b\,c}\right)^2}\,\right];$$

hence if the area, A, has a practically uniform run-off factor, m, throughout, and is larger than A_1, corresponding to t_1, the maximum flood discharge will occur for a rainfall of maximum uniform

Mr. Kuichling. intensity, i_1, corresponding to a duration of t_1 minutes, such duration being shorter than necessary to permit all portions of the entire area, A, to contribute at the same time to the discharge at the point of observation at the foot of the territory. For example, assume that m is constant $= 0.5$, and that the relation between A and t can be expressed by $A = 0.5t^2(1-0.01t)$, giving

for.... $t =$	10	20	30	40	50	60	70 minutes,
the area $A =$	45	160	315	480	625	720	735 acres;

also assume $i = \frac{120}{t + 20}$, and that the run-off is retarded 10 minutes, for the reasons mentioned above. We thus have $b = 20 + 10 = 30$, and $C = 0.01$, whence $t_1 = 57.3$ minutes, $A_1 = 701.2$ acres and $Q_1 = 482$ cu. ft. per sec., whereas if the entire area, $A = 735$ acres, and the entire time, $t = 70$ minutes, had been taken, the discharge would have been $Q = 441$ cu. ft. per sec. On the other hand, if the drainage area, A, were only 625 acres in extent, with its relation to t remaining the same as before, the maximum discharge would occur for a rainfall of maximum uniform intensity, i, corresponding to a duration of $t = 50$ minutes, or just sufficient to permit all portions of the territory to contribute at the same time to the run-off.

The foregoing example is similar to one which occurred in the speaker's practice, except that the difference between Q_1 and Q was considerably more than 10 per cent. It has been presented merely to illustrate a rational mode of procedure in the storm-water drainage of urban districts, and the necessity for maximum rainfall data based on uniform instead of average intensities. It may also be added that, while precipitation records of long duration and uniform intensity are rare, there are many such of short duration up to about 1 hour, and the tabulation of these for different localities will be of great service in municipal drainage operations, as it seldom happens that an urban district is so large and flat that the storm flow from its upper part to the final outfall will occupy more than 1 hour.

Mr. Le Conte. L. J. LE CONTE, M. AM. SOC. C. E. (by letter).—The intensity of rainfall for short periods of time is now being studied more carefully by weather observers, and, as a result, much valuable information is being obtained.

The older rainfall records at San Francisco are not by any means as complete as they might be, but, during later years, fortunately, the records of the United States Weather Bureau are available, and these are very much more in detail, and are quite reliable.

The older records were chiefly confined to San Francisco and Sacramento, and, while the results of intensity seem to be very

Mr. Le Conte.

meager when compared with those at Boston, nevertheless, they are equally interesting and important, from an engineering point of view.

The oldest intensity record, worthy of the name, is that of the noted rainstorm of December 19th and 20th, 1866. The intensity recorded was not extraordinary, *viz.*, 0.76 in. per hour, but the continuity, extending over 3 consecutive hours, is most remarkable for the Pacific Coast. Also, the total rainfall of 7.76 in. in 21 hours is phenomenal.

From this date until some time after the advent of the U. S. Weather Bureau, which began operations in March, 1871, no intensity records were taken; but intensity observations for shorter intervals of time, *i. e.*, for 1 hour and less, were not observed regularly previous to 1893. Since that date there is a tolerably fair record, which is full of interesting detail. It is thought best to put these results in tabular form (Table 3), as it is so much more convenient for reference.

TABLE 3.

Dates.	Rainfall, in inches.	Duration, in minutes.	Intensity, in inches per hour.
December 19, 1866	7.76	1 260	0.37
" " "	1.97	300	0.40
" " "	2.27	180	0.76
" " "	0.85	125	0.41
" " "	1.20	190	0.38
" 20, "	1.47	485	0.20
January 20, 1894	0.36	60	0.36
" " "	0.19	10	1.14
" " "	0.16	5	1.92
November 23, 1896	0.55	60	0.55
" " "	0.14	10	0.84
" " "	0.08	5	0.96
October 12, 1899	0.09	5	1.08
February 22, 1901	0.21	10	1.26
" " "	0.17	5	2.04
October 23, 1902	0.20	10	1.20
" " "	0.16	5	1.92
January 27, 1903	0.06	2	1.80
February 7, 1903	0.23	10	1.38
" " "	0.19	5	2.28

The data (in Table 3) are kindly furnished chiefly by Professor Alexander G. McAdie, of the U. S. Weather Bureau, San Francisco, Cal.

Perhaps it is a little too early to deduce a reliable intensity curve for San Francisco from the available data in Table 3, but, nevertheless, the writer found, on trial, that the curve follows very closely the simple expression, $i = \frac{7}{t^{0.5}}$, in which i = intensity of rainfall, in inches per hour, and t = duration, in minutes. For other cities

Mr. Le Conte. along the Pacific Coast, it may be different, of course, and the writer would like to have the matter discussed.

Mr. Venable. WILLIAM MAYO VENABLE, ASSOC. M. AM. SOC. C. E.—In connection with this paper, reference might be made to a report presented to the Drainage Commission of New Orleans, La., some years ago by a special committee of engineers: Messrs. Rudolph Hering, B. M. Harrod, Henry B. Richardson and L. W. Brown, all Members of this Society. This was a report on the plan proposed for the drainage of New Orleans, which has since been partially carried into effect. It contains tables showing carefully collected data regarding the rainfall of New Orleans for a number of years. The report was printed, but the supply of copies for distribution has been exhausted. Nevertheless, the data are obtainable by those who are interested. Similar data have been obtained in that city since the publication of the report referred to and may be found in the records of the office of the Drainage Commission which was succeeded a year or more ago by the Sewerage and Water Board, of which George G. Earl, M. Am. Soc. C. E., is General Superintendent and Chief Engineer.

The speaker spent some years in New Orleans in the construction of drainage canals and pumping stations, representing the contractor who built the greater part of the work already finished on the drainage system, and thus had occasion to observe closely several very heavy rainfalls, and the rapidity with which the water found its way into the drainage system. In one storm, about two years ago, more than 8 in. of rain fell in 24 hours, and most of it fell in 3 or 4 hours. The city is almost flat, and especially in the rural parts, it takes the water considerable time to reach the canals, where it can be pumped.

The run-off is the controlling element in the design of drainage works where the surface is not paved, and especially where the canals or sewers are a considerable distance apart.

It would be very risky to base the design of a sewer for drainage purposes on general conditions of rainfall or of run-off, such as an average for the entire United States, because the factors to be taken into account are so various, and the damages to be sustained from the flooding caused by exceptional storms are so different in different places. For instance, the damage which might be caused by furnishing too small an outlet for an area where water would accumulate to any considerable depth is not comparable to that which might be caused in a comparatively flat territory, where the utmost injury that could occur would be the standing of a few inches on the surface for a few hours while the sewer was relieving the land of the excess.

During the summer of 1904, at Leavenworth, Kans., the speaker

Mr. Venable.

witnessed an exceptional rainfall. A culvert, serving to drain a considerable part of the city, proved to be too small, and, as a result, the water backed up and wrecked a number of dwelling-houses. The water came so suddenly, at night, that the people had no warning before the flood was upon them; and yet there had never been any flood there before, and the Missouri River was only a few hundred yards away, with a surface level of 15 or 20 ft. below.

Mr. Burns.

C. S. Burns, M. Am. Soc. C. E. (by letter).—The writer is pleased to note the painstaking manner in which the author has presented the data concerning the rainfall at Boston. It is to be hoped that additional data will follow in discussions concerning the converse problem, where data are available concerning the actual run-off over spillways passing the flood volume from known areas.

The writer has a record of an instance at Cherryvale, Kans., where the discharge over the spillway from a small storage reservoir would seem to indicate that the rate of rainfall must have been much in excess of that indicated by the theoretical curve, $i = \frac{25.12}{t^{0.687}}$ The records in the writer's possession are not from personal observation, but are measurements taken by the engineer in charge of the reservoir in question, and there is no reason to doubt their approximate accuracy. The reservoir was designed by the writer, therefore he is correct on the following points:

The area of the water-shed above the spillway is 1 283 acres. The spillway is designed so that the run-off can be computed with considerable accuracy for any known head over the weir. In the particular instance in question, the depth of water flowing over the weir, as indicated by the gauge, was reported by the engineer in charge as 3 ft. This, for the weir in question, gives a theoretical discharge of 1 860 cu. ft. per sec. The drainage area is slightly undulating, but comparatively level, and it is estimated from observation that the time of concentration of the run-off from the whole water-shed is approximately 2 hours. Taking, then, a storm of 2 hours' duration, the intensity of the rainfall, from the author's curve, would be approximately at the rate of 1 in. per hour. Water falling on the entire water-shed at the rate of 1 in. per hour would indicate a total rainfall of approximately 1 300 cu. ft. per sec., while the character of the water-shed in question would not lead one to anticipate greater than 50% run-off after making proper allowance for pondage and water otherwise held back or retarded. It seems, then, that the actual measured run-off in the instance cited was approximately three times the theoretical run-off computed from the author's formula, after making the usually accepted corrections for retardation of flow. In this particular instance, the excessive run-off

Mr. Burns. cited was caused by the very first rain storm after the newly completed reservoir had been filled by several storms of minor intensity. No harm was done, due to the fact that the main body of the dam was designed with a view to the ultimate raising of the spillway at least 4 ft. in case future requirements should make greater storage necessary.

MEMOIRS OF DECEASED MEMBERS.

NOTE.—Memoirs will be reproduced in the Volumes of *Transactions*. Any information which will amplify the records as here printed, or correct any errors, should be forwarded to the Secretary prior to the final publication.

DANFORTH HURLBUT AINSWORTH, M. Am. Soc. C. E.*

DIED APRIL 24TH, 1904.

Danforth Hurlbut Ainsworth was born at Cape Vincent, New York, on March 8th, 1828, and died in Des Moines, Iowa, on April 24th, 1904. His ancestors were among the 20 000 or 25 000 persons who migrated to New England before the Long Parliament, through dissatisfaction with the laws of England, as administered by Charles I and Archbishop Laud, instead of staying at home to put a working edge on their discontent.

Mr. Ainsworth's immediate ancestors were land owners in Roxbury, Massachusetts, and in Woodstock, Connecticut, and in 1774 moved to Vermont. During both the French and Indian and the Revolutionary Wars they took an active part in the service of their country. Mr. Ainsworth's father moved to Cape Vincent, about 80 years ago, where his active business life was spent in lumbering, potash making, storekeeping, shipbuilding, and trading, mostly, to Montreal and Quebec, until the Papineau Rebellion.

In 1846 Mr. Ainsworth entered Geneva (now Hobart) College, where he was a member of the Sigma Phi Society, graduating in 1850. His first work was as Leveler on the enlargement of the Erie Canal. A change in the politics of the State sent him on the construction of the Syracuse and Binghamton Railroad for a year, from which he went to the Mississippi and Missouri, now a part of the Rock Island System, where, under the late S. B. Reed, M. Am. Soc. C. E., he staked out the first 55 miles west of the Mississippi, though neither he nor Mr. Reed were responsible for that location, which was abandoned long ago.

In the spring of 1854, a change in the political convictions of the State having occurred, Mr. Ainsworth went back to the service of the State of New York as First Assistant Engineer on the Erie Canal. This position required an affidavit to each estimate of work done:

"I and my sworn Assistants have accurately measured the work done since the last estimate: that the present estimate is not in excess, and that to the best of my knowledge and belief, all former estimates are correct."

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* Memoir prepared by Edward P. North, M. Am. Soc. C. E.

As the last part of this affidavit was not in accord with his knowledge and belief, it was stricken out before signing the affidavit. Although both the Division and State Engineers upheld this decision not to regard the usual affidavit as entirely *pro forma,* so much annoyance resulted that after some 18 months he returned to the Mississippi and Missouri.

From that time until he gave up professional work, virtually all his time was occupied west of the Mississippi, and most of it west of the Missouri. His power of fitting a location to the ground was probably better developed than that of any of his contemporaries, and no Engineer can ask a fairer monument to his painstaking skill than a comparison between the lines of the Chicago, Burlington and Quincy Railroad, east and west of the Missouri, as they were when opened to traffic.

Nor were his services in connection with the Eastern terminus of the Union Pacific Railroad less skilful, though, through local influence on Congress, that company was forced to adopt a line with higher grades, as set forth in several Congressional documents of 1865.

Mr. Ainsworth frequently wrote for technical and other papers, and notably aided the *Railroad Gazette* in its exposure of the fallacious arguments used by the narrow gauge promoters of thirty-five years ago.

He was a militant member of the Protestant Episcopal Church, carrying a sound and healthy religion into every-day life, where it was exhibited in a self-respecting regard for the duties and rights of himself and others, and by a high standard of morality and honesty.

Mr. Ainsworth was elected a Member of the American Society of Civil Engineers on March 3d, 1886.

ALPHONSE FTELEY, Past-President, Am. Soc. C. E.*

DIED JUNE 11TH, 1903.

Alphonse Fteley was born in Paris on April 10th, 1837, was educated in France, took the academic degree from the University of France, and, later, was graduated from L'École Polytechnique in 1859. From 1881 to 1884 he was a member of the Committee of Visitors to the Lawrence Scientific School of Harvard University, and, in 1898, he received from Columbia University the degree of M. A.

He began his professional life in France in 1859, and continued there in the general practice of his profession until 1865, when he came to the United States. He located in New York City, and in 1866 entered the office of the late William E. Worthen, Past-President, Am. Soc. C. E., as his general assistant, remaining with him until 1870. Then he opened an office, at 63 Bleecker Street, for general practice, in which he continued until 1873, when he was engaged by the Boston Water Board, under the City Engineer, Joseph P. Davis, M. Am. Soc. C. E., to be Resident Engineer in charge of the construction of the Sudbury River water-works system for the City of Boston. This work, costing about $5 000 000, was at that time considered as among those of the first importance in this country. It comprised several reservoirs, dams, etc., an aqueduct, 15.9 miles long, crossing two valleys on stone arch bridges, and was very successfully carried out. In connection with this work, Mr. Fteley carried out a series of observations for gauging the flow of the Sudbury River. These observations were conducted with great care and skill. With his assistant, F. P. Stearns, M. Am. Soc. C. E., he also conducted a series of experiments on the flow of water over weirs.

In 1880, upon the election of Assistant City Engineer Henry M. Wightman as City Engineer of Boston, Mr. Fteley was appointed Assistant City Engineer, and was engaged in designing many important structures, especially for the Water-Works, Main Drainage and Park Systems of the city, until 1884 when he left the service of the City of Boston to accept, from the Aqueduct Commission of New York City, the position of Principal Assistant Engineer on the new Croton Aqueduct, under Mr. Benjamin S. Church, the Chief Engineer.

In 1886 his title was changed to Consulting Engineer, and, in 1888, upon the retirement of Mr. Church, he was appointed Chief

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*Memoir prepared by the following Committee: William Jackson, Joseph P. Davis, Charles S. Gowen and Charles Warren Hunt, Members, Am. Soc. C. E.

Engineer. As Principal Assistant Engineer to Mr. Church, he had charge of the design of the aqueduct, of a dam for the Quaker Bridge site and of other important dams, structures and reservoirs and also of the preparation of the specifications and contracts for their construction. After his appointment as Chief Engineer investigations were renewed for the location and design of the proposed dam to complete the storage of the Croton water-shed, and it was decided to build the New Croton Dam at a point some distance up stream from the Quaker Bridge site.

He was exceptionally qualified by his experience to design and to direct the construction of works of this class, and was, without doubt, one of the best authorities of his time. Mr. Fteley continued his connection with this work until 1899 when he was compelled by ill health to resign and retire from the active practice of his profession. With the exception of the New Croton Dam and the Jerome Park Reservoir, all the important features of the Croton water supply were completed before his retirement.

Mr. Fteley was also engaged in an advisory capacity, and was consulted on many important engineering works. Mention may be made of the following: The works and studies under the charge of the Metropolitan Water Board of Massachusetts; of the Sewerage Commission of New Jersey; of the Rapid Transit Commission of New York City; of the Boston Rapid Transit Commission of 1892; of the Cataract Construction Company, of Niagara Falls, New York; of the Schuylkill Navigation Company; of the Board of Works of Newark, New Jersey; the Aqueduct Tunnel repairs of Washington, D. C.; the additional water supply of Rochester, New York; the supply of water to New York City from New Jersey; the additional water supply for Cincinnati, Ohio; and the additional supply for Brooklyn, New York. He was also a member of the Comité Technique of the New French Panama Canal Company.

Mr. Fteley was elected a Member of the American Society of Civil Engineers on January 5th, 1876, and in 1879 read a paper before it entitled "The Flow of the Sudbury River, Massachusetts, for the Years 1875 to 1879."* Three years later, in collaboration with his asistant, F. P. Stearns, M. Am. Soc. C. E., he presented what is perhaps his most valuable contribution to the science of hydraulics, a paper entitled "Description of Some Experiments on the Flow of Water Made during the Construction of Works for Conveying the Water of Sudbury River to Boston."† This paper received the award of the Norman Medal for 1882. He was active in the management of the Society for a number of years, serving as Director in 1888 and as Vice-President in 1889, 1890 and 1891. In 1898 he was elected President, and, from the expiration of his term to the time of his death, continued to take great interest in the affairs of the Society.

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* *Transactions*, Am. Soc. C. E., Vol. X, p. 225.

† *Transactions*, Am. Soc. C. E., Vol. XII, p. 1.

In 1874 Mr. Fteley was elected a member of the Boston Society of Civil Engineers, and of the New England Water Works Association.

Mr. Fteley married in 1869, in New York City, Elise Susanne Maurier, widow of Jules Breuchaud. He left a daughter and four step-children.

An obscure heart trouble from which he suffered during the last thirty years of his life, and which caused two severe illnesses of prolonged duration in 1879 and 1886, limited Mr. Fteley's capacity for work at times, although it seemed to have little effect on results. This was due to his remarkable perceptive faculties, thorough training, and breadth of view, through which he was able to grasp subjects quickly. It was also due to his natural executive capacity. In 1894 his general health began to fail, still further limiting his physical activity. That this in no wise impaired his courage and ability to direct is evident by the progress of the work of the Aqueduct Commissioners after that date and up to the time of his retirement as Chief Engineer, as well as by the important consultations undertaken by him from 1894 to 1901, of which his work as Consulting Engineer to the Metropolitan Water Board of Massachusetts, and as a member of the Comité Technique of the New French Panama Canal Company, can especially be recorded.

Continued failing health impelled his retirement from active duties at the end of 1899, and he died on June 11th, 1903, at his home in Yonkers, New York.

To an attractive and notable personality there was added a remarkable charm of manner which distinguished Mr. Fteley in his relations to all with whom he came in contact. The confidence inspired by his high character, and his kindliness and manifest broad sympathies, caused his subordinates to feel that in him they could always find a friend as well as a respected and acknowledged leader and master, and won the warm regard of every one. His judgments were always based on broad views of affairs, as well as upon intimate knowledge of the essential facts in each question, and they were accordingly abiding. The unlimited patience and generosity which he always exercised toward those who were in any way dependent upon or subordinate to him won their enthusiastic loyalty, and, in consequence, the best that there was in a man was always at his command. This was one of the reasons of Mr. Fteley's remarkable success as an executive, and made it possible for him to accomplish much while the condition of his health was such as to prohibit physical activity on his part. His last years were years of great suffering, owing to a complication of troubles, but his cheerfulness and fortitude did not fail, and he died as he had always lived, the embodiment of gentleness, patience and courage, having advanced to great achievements in the face of extraordinary difficulties, imposed by ill health, and the cares and anxieties resulting therefrom.

PROCEEDINGS

OF THE

AMERICAN SOCIETY

OF

CIVIL ENGINEERS.

(INSTITUTED 1852.)

VOL. XXXI. No. 4.
APRIL, 1905.

Edited by the Secretary, under the direction of the Committee on Publications.

Reprints from this publication, which is copyrighted, may be made on condition that the full title of Paper, name of Author, page reference, and date of presentation to the Society, are given.

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NEW YORK 1905.

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American Society of Civil Engineers.

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ON CONCRETE AND REINFORCED CONCRETE:—C. C. Schneider, J. E. Greiner, W. K. Hatt, Olaf Hoff, Robert W. Lesley, J. W. Schaub, Emil Swensson, A. N. Talbot, J. R. Worcester.

◆

The House of the Society is open from 9 A.M. to 10 P.M. every day, except Sundays Fourth of July, Thanksgiving Day and Christmas Day.

HOUSE OF THE SOCIETY—220 WEST FIFTY-SEVENTH STREET, NEW YORK.

TELEPHONE NUMBER, - - - 583 Columbus.
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Vol. XXXI. APRIL, 1905. No. 4.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PROCEEDINGS.

This Society is not responsible, as a body, for the facts and opinions advanced in any of its publications.

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MINUTES OF MEETINGS.

OF THE SOCIETY.

April 5th, 1905.—The meeting was called to order at 8.40 P. M.; President Schneider in the chair; Chas. Warren Hunt, Secretary, and present, also, 94 members and 18 guests.

The minutes of the meetings of March 1st and 15th were approved as printed in the *Proceedings* for March, 1905.

A paper by H. C. V. Möller, Esq., entitled "A New Swing Bridge at Copenhagen, Denmark," was presented by the Secretary, who also presented a written communication on the paper from John C. Moses, M. Am. Soc. C. E. The subject was discussed orally by Messrs. J. A. L. Waddell, H. T. Forchhammer and E. Kuichling.

Ballots for membership were canvassed, and the following candidates elected:

As Members.

James Aubrey Davenport, Roanoke, Va.
William Ashton Doble, San Francisco, Cal.
James Edwin Garrett, Naica, Chihuahua, Mexico.
William Edward Gunn, Covington, Ky.
Joseph Arnold Norcross, New Haven, Conn.
John Stephen Sewell, Washington, D. C.

As Associate Members.

Asher Atkinson, New Brunswick, N. J.
Arthur Horace Blanchard, Providence, R. I.
William Whitlock Brush, Brooklyn, N. Y.
Sidney Kingman Clapp, Boston, Mass.
Philip Herrick Dater, Rochester, N. Y.
Edwin Clifford Finley, St. Louis, Mo.
Frank Lawton Getman, Hudson, N. Y.
John Wesley Goodridge, New York City.
Jerome Campbell Herring, Jefferson City, Mo.
Bertram Henry Majendie Hewett, New York City.
Caleb Hyatt, New York City.
Alexander Howard Nelson, Pittsburg, Pa.
Algernon Sidney Nye, New York City.
Shelby Saufley Roberts, Elizabethtown, Ky.
Rudolf Viedt Rose, Niagara Falls, N. Y.
Robert Wilson Sayles, New York City.
Charles Depew Searle, New York City.
Henry Radclyffe St. Arvans Walters, Bethlehem, Pa.
Eitaro Watanabe, Taipeh, Formosa, Japan.
Gilbert Case White, Winston-Salem, N. C.
Clarence George Wrentmore, Ann Arbor, Mich.

As Associates.

Thomas Frank Quilty, Chicago, Ill.
Gilbert Hilton Scribner, Jr., Chicago, Ill.

The Secretary announced:

The transfer of the following candidates, by the Board of Direction, on April 4th, 1905:

From Associate Member to Member.

George Elliot Browning, Trichur, South India.
Harrison Wainwright Latta, Philadelphia, Pa.
Moses Jerome Look, Clinton, Mass.
James Cowan Meem, Brooklyn, N. Y.

HARRY JOHNSON MORRISON, Syracuse, N. Y.
JOHN EDWIN OSTRANDER, Amherst, Mass.
CLARENCE DUBOIS POLLOCK, Brooklyn, N. Y.
JAMES WALTER RICKEY, Minneapolis, Minn.
GEORGE ALBERT SOPER, New York City.
CHARLES FREDERICK TAYLOR, New York City.

The election of the following candidates, by the Board of Direction:

AS JUNIORS.

On December 6th, 1904.
ALFRED HANSON HARTMAN, Elkton, Md.

On April 5th, 1905.
HENRY AVERY CAMPBELL, Coyote, Cal.
ARDEN DUANE DOTY, New York City.
RICHARD KING HALE, Brookline, Mass.
HERBERT WATSON HATTON, Wilmington, Del.
DONALD WINTHROP HOWES, New York City.
THOMAS BENTON HUNTER, Monterey, Cal.
WALTER EDWARD LYDSTON, Auburn, N. Y.
JOHN LORENZO McCONNELL, Louisville, Ky.
JAMES MICHAEL OWENS, San Francisco, Cal.
DAVID JOSEPH SHAW, New York City.
THOMAS PATTON STEVENSON, Paramaribo, Dutch Guiana.
WILLIAM ADAMS TREADWELL, Albany, N. Y.
WILLIAM FRANKLIN WHITAKER, Bakersfield, Cal.

The Secretary announced the following deaths:

BURR BASSELL, elected Member November 4th, 1903; died February 24th, 1905.

FREDERICK DE FUNIAK, elected Member May 7th, 1873; died March 29th, 1905.

Adjourned.

April 19th, 1905.—The meeting was called to order at 8.40 P. M.; President C. C. Schneider in the chair; Chas. Warren Hunt, Secretary; and present, also, 125 members and 15 guests.

A paper, entitled "The Reconstruction of the Baltimore and Ohio Railroad Bridge over the Ohio River, at Benwood, West Virginia," by J. E. Greiner, M. Am. Soc. C. E., was presented by the Secretary. The paper was discussed by Messrs. O. E. Hovey and O. E. Mogensen.

The Secretary announced the following deaths:

GEORGE ANSON MARR; elected Member October 3d, 1883; died March 24th, 1905.

GEORGE ANTHONY LEDERLE; elected Junior May 2d, 1883; Member October 6th, 1886; died March 27th, 1905.

Adjourned.

OF THE BOARD OF DIRECTION.

(Abstract.)

April 4th, 1905.—President Schneider in the chair; Chas. Warren Hunt, Secretary, and present, also, Messrs. Bissell, Bowman, Craven, Deyo, Ellis, Knap, Kuichling, N. P. Lewis, Noble, Osgood and Webster.

The Building Committee was requested to secure bids on plans for the addition to the present building, and to report to the Board at a Special Meeting to be held April 20th, 1905.

The Board ordered that a discount of 50% be allowed, on the volumes of the International Engineering Congress papers, to members of the Society elected after December 31st, 1904.

Applications were considered, and other routine business transacted.

Ten Associate Members were transferred to the grade of Member, and thirteen candidates for Junior were elected.

Adjourned.

ANNOUNCEMENTS.

The House of the Society is open from 9 A. M. to 10 P. M. every day, except Sundays, Fourth of July, Thanksgiving Day and Christmas Day.

MEETINGS.

Wednesday, May 3d, 1905.—8.30 P. M.—A regular business meeting will be held. Ballots for membership will be canvassed, and two papers will be presented for discussion, as follows: "Round-House Framing," by R. D. Coombs, Assoc. M. Am. Soc. C. E., and "A Few Remarks on Foundations," by L. L. Buck, M. Am. Soc. C. E.

Both these papers are printed in this number of *Proceedings.*

Wednesday, May 17th, 1905.—8.30 P. M.—At this meeting a paper entitled "The Irrigation System of Ontario, California," by F. E. Trask, M. Am. Soc. C. E., will be presented for discussion.

This paper is printed in this number of *Proceedings.*

Wednesday, June 7th, 1905.—8.30 P. M.—A regular business meeting will be held. Ballots for membership will be canvassed and two papers will be presented for discussion, as follows: "A Few Points in the Design of Reinforced Concrete Arches," by B. R. Leffler, Assoc. M. Am. Soc. C. E., and "Theory of the Spherical or Conical Dome of Reinforced Concrete or Metal," by William Cain, M. Am. Soc. C. E.

Both these papers are printed in this number of *Proceedings.*

ANNUAL CONVENTION.

The Thirty-Seventh Annual Convention will be held in Cleveland, Ohio, June 20th-23d, 1905. The following Committees have been appointed to take charge of the arrangements.

COMMITTEE OF THE BOARD OF DIRECTION:

Alfred Craven, *Chairman;*

N. P. Lewis,
Charles S. Gowen,
W. J. Wilgus,
Chas. Warren Hunt.

LOCAL COMMITTEE:

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Wm. J. Carter,
Harry Fuller,
E. A. Handy,
A. M. Johnston,
M. W. Kingsley,
J. Francis Le Baron,
F. C. Osborn,
W. P. Rice,
J. Ritchie,
W. H. Searles,
S. T. Wellman,
C. H. Wright.

PRIVILEGES OF LOCAL SOCIETIES EXTENDED TO MEMBERS OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS.

The Boston Society of Civil Engineers will welcome any member of the American Society of Civil Engineers at its library and reading room, 517 Tremont Temple, Boston, which is open on week days from 9 A. M. to 5 P. M. Members will also be welcome at the meetings, which are held in the same building, on the evenings of the fourth Wednesday in January, and the third Wednesdays of other months, except July and August.

The rooms of **The St. Louis Engineers' Club** are in the business center of St. Louis, and visiting engineers are cordially invited to use them for mail, telephone service, information, etc.

The courtesies of **The Engineers' Society of Western Pennsylvania** have been extended to members of the American Society of Civil Engineers. The rooms of the Society, 410 Penn Ave., Pittsburg, Pa., are open at all times, and meetings are held as follows, except during July and August. REGULAR SECTION, Third Tuesdays; CHEMICAL SECTION, Thursdays following third Tuesdays; MECHANICAL SECTION, First Tuesdays; STRUCTURAL SECTION, Fourth Tuesdays.

The Western Society of Engineers, Monadnock Block, Chicago, Ill., tenders to members of this Society the use of its rooms and facilities, together with the good offices of its Secretary and of a special committee appointed for that purpose.

The Civil Engineers' Club of Cleveland, Ohio, invites members of this Society to make use of the Club rooms, at any time when in Cleveland. Cards will be furnished on application to the Secretary, Mr. J. C. Beardsley.

The Engineers' Club of Central Pennsylvania has established new quarters at the corner of Second and Walnut Streets, Harrisburg, Pa., and desires to extend the courtesies of the Club to visiting members of the American Society of Civil Engineers.

SEARCHES IN THE LIBRARY.

In January, 1902, the Secretary was authorized to make searches in the Library, upon request, and to charge therefor the actual cost to the Society for the extra work required. Since that time many such searches have been made, and bibliographies and other information on special subjects furnished.

The resulting satisfaction, to the members who have made use of the resources of the Society in this manner, has been expressed frequently, and leaves little doubt that, if it were generally known to the membership that such work would be undertaken, many would avail themselves of it.

The cost is trifling, compared with the value of the time of an

engineer who looks up such matters himself, and the work can be performed quite as well, and much more quickly, by persons familiar with the Library.

Copies of all lists of references are filed, so that in many cases it is only necessary to make a typewritten copy, which reduces the cost of searches to a minimum.

In asking that such work be undertaken, members should specify clearly the subject to be covered, and whether references to general books only are desired, or whether a complete bibliography, involving search through periodical literature, is desired.

INTERNATIONAL ENGINEERING CONGRESS PUBLICATIONS.

The first three volumes of the Proceedings of the International Engineering Congress have been distributed to all Members elected prior to December 31st, 1904. There will be six volumes in all. Members have been notified that they would receive these volumes (issued as Parts A, B, C, D, E and F of Vol. LIV of *Transactions*) and asked whether they wished them bound in one of the Standard Bindings. A number of Members who have their Volumes bound regularly have not responded, and consequently will receive these volumes in paper covers, unless an order is received at once for their binding. It is urged that all who care to have these volumes bound, and who have not already done so, send in an order for such binding immediately.

The notation of these volumes, as Parts of one of the regular volumes of *Transactions*, was adopted for the convenience of Members, so that when all are received they will be consecutive on the shelf. It was not possible at the time to say how long it would take to collate the discussions and issue these volumes, and it was thought best to issue them as Parts of Vol. LIV.

It is now expected that at least five of these volumes, and possibly all, may be forwarded to Members prior to the date they will receive the regular Volume LIV, and this explanation is given so that the membership may understand that, for them, there will be seven Parts of Vol. LIV, and that the regular Volume whose shelf place should be first, will probably not be received until after these Engineering Congress Publications.

ACCESSIONS TO THE LIBRARY.

From March 8th to April 11th, 1905.

DONATIONS.*

MÉTALLURGIE DU ZINC.

Par A. Lodin. Paper, 10 x 6 in., illus., 810 pp. Paris, Vve. Ch. Dunod, 1905. 35 francs.

The preface states that information, in a condensed form, on zinc in its natural state is contained in the preliminary chapters. Then follows an account of the preparatory operations of the metallurgy of zinc, as roasting and calcining, according to the general conditions prevailing in Europe. It is stated that the principal object of the book is a description of the production of zinc by reduction and distillation in closed vessels, a complete history of the methods practiced in the past and at the present time. The accessory operations which exert a considerable influence on the final results are studied in every detail. The attempts of a number of inventors to use some other method are discussed. The publication of the present work is intended to eliminate the mystery surrounding the metallurgy of zinc and to furnish to those occupied with this industry a means of controlling the results obtained, methodically improving them by following a rational and scientific method. There is a classified index of thirteen pages.

A HANDBOOK FOR SUPERINTENDENTS OF CONSTRUCTION, ARCHITECTS, BUILDERS AND BUILDING INSPECTORS.

By H. G. Richey. Leather, 7 x 4 in., illus., 744 pp. New York, John Wiley & Sons, 1905. $1.

The preface states that this book was intended to be an every-day help to anyone engaged in building construction, and the author has tried to make it as complete and up-to-date as possible. Immediately following the preface is a list of works, author's and magazines on this subject; and the dates of the various building codes from which extracts have been taken. The book also contains, A Glossary of Names of some New Materials Used in Building. There is an index of forty-seven pages.

SUCTION GAS.

By Oswald H. Haenssgen. Cloth, 7 x 5 in., illus., 4 + 88 pp. Cincinnati, The Gas Engine Publishing Co., 1904. $1.

The preface states that this work has been published with a view of supplying the increasing demand for information on this subject in America. The design, operation, cost of running, development and possible utility of this type of gas producer are all covered in this book. There is an index of two pages.

A TREATISE ON CONCRETE PLAIN AND REINFORCED.

Materials, Construction and Design of Concrete and Reinforced Concrete. By Frederick W. Taylor and Sanford E. Thompson, Assoc. M. Am. Soc. C. E. Cloth, 9 x 6 in., illus., 18 + 585 pp. New York, John Wiley & Sons, 1905.

The preface states that this treatise is designed for practicing engineers and contractors, and also for a text and reference book for engineering students. The chapters are arranged for convenience in reference, and therefore are not always in logical order. The Concrete Data in Chapter I. presents a list of definitions and terms. The Elementary Outline of the Process of Concreting; Specifications for Cement, including the latest recommendations of committees of the societies; Classification of Cements distinguishing the various cements and limes manufactured in the United States and Europe, are among the subjects discussed. Plain and Reinforced Concrete Structures are treated in as much detail as space permits, in Chapters XXII to XXVII inclusive; methods of Cement Manufacture in its modern types are described in detail in Chapter XXVIII. This is followed by a list of References to Concrete Literature. The chapter entitled The Effect of Sea Water has been written by Mr. René Feret, of Boulogne-sur-Mer, France, who has made extended researches, and the subject Proportioning Concrete has been treated by Mr. William B. Fuller, and his practical use of mechanical analysis is fully discussed. There is an index of twelve pages.

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* **Unless otherwise specified, books in this list have been donated by the publishers.**

CEMENT AND CONCRETE.

By Louis Carlton Sabin, M. Am. Soc. C. E. Cloth, 9 x 6 in., 10 + 507 pp. New York, McGraw Publishing Company, 1905. $5.

The preface states that this book is an attempt to place in one volume a connected story of the properties and uses of cement, giving, where practicable, sufficient tests to support the statements made, and endeavoring to show the connection between theory and practice, the laboratory and the field. The original investigations forming the basis of the work were made in connection with the construction of the Poe Lock at St. Mary's Falls Canal, Michigan, under the direction of the Corps of Engineers, U. S. Army. When not otherwise stated, the tables in the work are condensed from the results of these investigations. There is an index of eleven pages.

THE GRAPHIC METHOD BY INFLUENCE LINES FOR BRIDGE AND ROOF COMPUTATIONS.

By William H. Burr, M. Am. Soc. C. E., and Myron S. Falk, Jun. Am. Soc. C. E., Cloth, 9 x 6 in., illus., 253 pp. New York, John Wiley & Sons, 1905. $3.

The preface states that this book exhibits an entirely modern graphical treatment by the method of influence lines, of simple statically determinate structures such as bridges and roof-trusses, three-hinged arches, cantilevers and other constructions of the same general class. The simplicity, elegance, and generality of procedures by influence lines and areas afford quick and eminently practical methods of computing stresses in all forms of trusses, whether with straight, curved, or broken outlines, and with any single or multiple systems of bracing, whether square or skew, or with any manner of loading whatever. This covers plate girders and solid beams, as well as articulated or jointed structures like ordinary bridge- and roof-trusses. The stresses in roof-trusses caused by the flexure of the supporting columns are treated in detail. A sufficient number of problems are introduced to illustrate clearly the practical applications of the various methods of treatment; and the complete design of the members of a railroad bridge are given at the end of the book, to which, in the determination of the stresses, the previously deduced methods are applied. The application of these lines to statically indeterminate structures, will appear in another volume. There is an index of seven pages.

SMOKE PREVENTION AND FUEL ECONOMY.

Based on the German Work of E. Schmatolla. By Wm. H. Booth, M. Am. Soc. C. E., and John B. C. Kershaw. Cloth, 9 x 6 in., illus., 194 pp. New York, The Norman W. Henley Publishing Co., 1905. $2.50.

The preface states that the object of this book is to bring before the fuel-using public, in as brief a manner as possible, the principles of fuel combustion, and the means by which the practice of fuel combustion has been carried out. The book has grown around the author's original idea of presenting a simple translation of the German book of Ernst Schmatolla, to which the author found it necessary to add much to fit the book to English practice and to subtract other less suitable matter. It is illustrated by a few examples of English and American appliances, and mechanical stokers; which appear to fulfil the necessary requirements of thorough mixture of gases and air at a high temperature. The book contains: The Chemistry of the Combustion Process; Present Methods of Burning Fuels and their Defects; Improved Methods of Burning Fuel; The Examination of the Waste Gases, and Control of the Combustion Process. The Appendix contains, abstracts of English, German and United States patents; fuel analysis and miscellaneous extracts. There is an index of six pages.

STRUCTURAL DESIGNERS' HANDBOOK.

Giving Diagrams and Tables for the Design of Beams, Girders and Columns, with Calculations Based on the New York City Building Code. By William Fry Scott. Cloth, 9 x 6 in., illus., 8 + 158 pp. New York, Engineering News Publishing Co., 1904. $2.

The preface states that this book is essentially a diagrammatic treatise on the subject of structural design; containing a full tabulation of the properties of market shapes of materials. Its object is to shorten and possibly eliminate much of the computation and drudgery which are necessary accompaniments of structural designing. The diagrams presented are time-saving devices and illustrate graphically the relations of the various factors of proportion, span loading, etc., for the variable conditions of ordinary practice. Throughout the work the New York Building Code has been followed. Contents: Part I, Synopsis of Mechanics of the Beam and Column; Part II, Beamwork; Part III, Colum and Truss Members; Part IV, Miscellaneous. There is an index of six pages

Gifts have also been received from the following:

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Willmon, J. C. 1 bound vol.
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Worcester, Mass.—Supt. of Sewers. 1 pam.

BY PURCHASE.

The World Almanac and Encyclopedia, 1905. New York, The Press Publishing Co., New York *World*, 1904.

Brooklyn Daily Eagle Almanac, 1905, a Book of Information General of the World and Special of New York City and Long Island. New York, Brooklyn *Daily Eagle*, 1905.

Fouilles et Fondations; à l'Air Libre, Sous l'Eau, à l'Air Comprimé, Déblais Souterrains; Tunnels, Béton Armé. Par P. Frick, Paris, Vve. Ch. Dunod, 1905.

Die Entwickelung des Niederrheinisch-Westfälischen Steinkohlen-Bergbaues in der Zweiten Hälfte des 19. Jahrhunderts. Vol. VII, Berieselung, Grubenbrand, Rettungswesen, Beleuchtung, Sprengstoffwesen, Versuchsstrecke. Berlin, Julius Springer, 1904.

Official Army Register, 1905. Washington, Secretary of War, 1904.

The Naval Constructor: A Vade Mecum of Ship Design for Students, Naval Architects, Shipbuilders and Owners, Marine Superintendents, Engineers and Draughtsmen. By George Simpson, New York, D. Van Nostrand Company, 1904.

Laboratory and Factory Tests in Electrical Engineering. By George F. Sever and Fitzhugh Townsend. New York, D. Van Nostrand Company, 1904.

Royal Commission on Sewage Disposal, Supplementary Volumes Presented with the Fourth Report of the Commissioners Appointed in 1898. Vol. IV, Part I.—General Report; Part II.—Chemical Report, by C. McGowan; Part III.—Bacteriological Report, by A. C. Houston; Part IV.—Engineering and Practical Report, by G. B. Kershaw; Part V.—Methods of Chemical Analysis as Applied to Sewage and Sewage Effluents. London, Eyre and Spottiswoode, East Harding Street, Fleet Street, E. C.; and 32 Abingdon Street, Westminster, S. W., 1904,

Petrol Motors and Motor Cars, a Handbook for Engineers, Designers, and Draughtsmen. By T. Hyler White. New York, Longmans Green and Co., 1904.

The Telephone Service; its Past, its Present and its Future. By Herbert Laws Webb. London, Whittaker & Co., 1904.

Automatic Surveying Instruments and Their Practical Uses on Land and Water. By Thos. Ferguson. London, John Bale, Sons & Danielsson, Ltd., 1904.

Electric Motors; Continuous Current Motors and Induction Motors, Their Theory and Construction. By Henry M. Hobart. London, Whittaker and Co., 1904.

SUMMARY OF ACCESSIONS.

March 8th to April 11th, 1905.

Donations (including 16 duplicates)	182
By purchase	12
Total	194

MEMBERSHIP.

ADDITIONS.

		Date of Membership.
ANDREWS, HIRAM BERTRAND. 166 Devonshire St., Boston, Mass		Mar. 1, 1905
ARNOLD, BION JOSEPH. 1539 Marquette Bldg., Chicago, Ill		Mar. 1, 1905
BURT, HENRY JACKSON. Contr. Engr., Am. Bridge Co., of New York, 520 Dooly Bldg., Salt Lake City, Utah		Mar. 1, 1905
CHADBOURN, WILLIAM HOBBS, Jr. U. S. Asst. Engr., U. S. Engr. Office, Beaver, Pa	Jun. M.	Dec. 3, 1890 Mar. 1, 1905
CHAPLEAU, SAMUEL JEFFERSON. Dist. Engr., Georgian Bay Ship Canal, Dept. of Public Works, P. O. Box 347, Ottawa, Ont., Canada	Assoc. M. M.	May 1, 1901 Jan. 31, 1905
COUTLEE, CHARLES ROBERT FORAN. P. O. Box 1069, Ottawa, Ont., Can		Mar. 1, 1905
HAINES, FRANK MARCH. 2d Vice-Pres. and Gen. Mgr., Northern Texas Traction Co., 400 Main St., Fort Worth, Tex		Mar. 1, 1905
LATTA, HARRISON WAINWRIGHT. Pres., Latta & Terry Constr. Co., Pennsylvania Bldg., Philadelphia, Pa	Assoc. M. M.	Sept. 5, 1900 April 4, 1905
LOOK, MOSES JEROME. Div. Engr., Met. Water and Sewerage Board, 98 Walnut St., Clinton, Mass	Assoc. M. M.	May 6, 1903 April 4, 1905
MARDEN, WALTER REUBEN. Vice-Pres. and Chf. Engr., The United Constr. Co., 467 Broadway, Albany, N. Y	Assoc. M. M.	April 4, 1894 Feb. 28, 1905
MORRISON, HARRY JOHNSON. 513 Dillaye Memorial Bldg., Syracuse, N. Y	Assoc. M. M.	Jan. 4, 1899 April 4, 1905
MOULTON, GUY. Res. Engr., Middle Div., Dept. of State Engr. and Surv., 403 Bastable, Syracuse, N. Y		Mar. 1, 1905
NORCROSS, JOSEPH ARNOLD. Engr., New Haven Gas Light Co., 80 Crown St., New Haven, Conn		April 5, 1905
OSTRANDER, JOHN EDWIN. Prof., Mathematics and Civ. Eng., Mass. Agri. Coll., Amherst, Mass	Jun. Assoc. M. M.	May 2, 1888 Sept. 2, 1891 April 4, 1905
PENFIELD, WILLIAM HENRY. Quincy, Plumas Co., Cal		Mar. 1, 1905
POLLOCK, CHARLES DUBOIS. Asst. Engr., Bureau of Highways, Municipal Bldg., Brooklyn, N. Y	Assoc. M, M.	Jan. 8, 1902 April 4, 1905
POPE, JOHN HORTON. Asst. Engr., J. G. White & Co., 43 Exchange Pl., New York City		Dec. 7, 1904
POWERS, CORNELIUS VAN VORST. 231 West 125th St., New York City		Mar. 1, 1905

		Date of Membership.
Smith, Cecil Brunswick. 36 Toronto St., Toronto, Ont., Canada		Mar. 1, 1905
Soper, George Albert. Cons. Engr. and San. Expert, 29 Broadway, New York City	Assoc. M. M.	Feb. 6, 1901 April 4, 1905
Soulé, Frank. Univ. of California, Berkeley, Cal		Mar. 1, 1905
Strouse, William Franklin. 400 Forest Rd., Roland Park, Baltimore, Md		Mar. 1, 1905
Taylor, Charles Frederick. Engr. and Contr., 913 Tremont Bldg., Boston, Mass.	Assoc. M. M.	Sept. 4, 1895 April 4, 1905

ASSOCIATE MEMBERS.

Atkinson, Asher. 49 Mine St., New Brunswick, N. J.		April 5, 1905
Blanchard, Arthur Horace. Asst. Prof. of Civ. Eng., Brown Univ.; Asst. Engr., State Board of Public Roads of Rhode Island, Brown Univ., Providence, R. I.	Jun. Assoc. M.	Jan. 2, 1900 April 5, 1905
Burdick, Charles Baker. 1207 Hartford Bldg., Chicago, Ill.		Mar. 1, 1905
Foote, Arthur Burling. Asst. Supt., North Star Mines Co., Grass Valley, Cal		Mar. 1, 1905
Hewett, Bertram Henry Majendie. Res. Engr., Penn., N. Y. & L. I. R. R. Co., 1 West 34th St., New York City		April 5, 1905
Hyatt, Caleb. 515 Lexington Ave., New York City	Jun. Assoc. M.	Mar. 3, 1903 April 5, 1905
Kreuger, Ivar. Care, Kreuger & Co., 10 Eastcheap, London, E. C., England		Dec. 7, 1904
Lytel, James Leonard. U. S. Geological Survey, Reclamation Service, Montrose, Colo		Jan. 4, 1905
Moorshead, Thomas Courtney. Supt., Litchfield & Madison Ry. Co., Edwardsville, Ill.		Mar. 1, 1905
Nelson, Alexander Howard. 402 Murtland Bldg, Pittsburg, Pa	Jun. Assoc. M.	Nov. 1, 1898 April 5, 1905
Nye, Algernon Sidney. Asst. Engr. to the Aqueduct Commrs., Kingsbridge, New York City	Jun. Assoc. M.	July 2, 1890 April 5, 1905
Parker, William Pool. 405 Thayer Bldg., Kansas City, Mo		Oct. 5, 1904
Proctor, Lewis Jefferson. Asst. Supt., Bureau of Public Works, San Juan, Porto Rico		Mar. 1, 1905
Rankin, Harry Howard. (Rankin & Hengst), 301 Smithfield St., Pittsburg, Pa		Mar. 1, 1905
Rose, Rudolf Viedt. Asst. Engr., The Niagara Falls Power Co., Niagara Falls, N. Y		April 5, 1905
Saunders, George Crosby. Mgr., Eastern Dist., The Osborn Eng. Co., 1022 Land Title Bldg., Philadelphia, Pa		Mar. 1, 1905

		Date of Membership.
Sayles, Robert Wilson. 15 Cortlandt St., New York City		April 5, 1905
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Wells, Clinton Glencairn. City Engr., Galveston, Tex.; Chf. Engr., Galveston & Western R. R.; Address, City Hall, Galveston, Tex.	Jun. Assoc. M.	Mar. 5, 1901 Mar. 1, 1905
White, Gilbert Case. Box Q, Winston-Salem, N. C.		April 5, 1905

ASSOCIATES.

Letson, Thomas Herbert. 39 Cortlandt St., New York City	Mar. 1, 1905

JUNIORS.

Anthony, Walter Loring. Asst. Engr., Care, The R. H. Tingley Co., 75 Westminster St., Providence, R. I.	Jan. 5, 1904
Bernstein, Lester. Morgantown, W. Va.	Feb. 28, 1905
Garman, Harry Otto. 739 Owen St., LaFayette, Ind.	Feb. 28, 1905
Hale, Richard King. Chestnut Hill Ave., Brookline, Mass	April 4, 1905
Hansen, Paul. 2124 Farmers Bank Bldg., Pittsburg, Pa.	Jan. 3, 1905
Hatton, Herbert Watson. 608 Market St., Wilmington, Del	April 4, 1905
Longley, Francis Fielding. 38 Stone St., Watertown, N. Y.	Feb. 28, 1905
McConnell, John Lorenzo. 414 W. Oak St., Louisville, Ky.	April 4, 1905
Park, James Caldwell. 52A Winslow St., Watertown, N. Y.	Feb. 28, 1905
Schultz, Charles. 307 North Third St., Hannibal, Mo.	Nov. 1, 1904
Tozzer, Arthur Clarence. 35th St. and East River, New York City	April 4, 1905
Weidner, Carl Robert. Independence, Kans.	Feb. 28, 1905

CHANGES OF ADDRESS.

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Appleton, Thomas	Supt. of Constr., U. S. Post Office, Custom House and Court House, Wheeling, W. Va.
Barnard, John Fiske	511 West 23d St., Los Angeles, Cal.
Bates, Onward	Pres., Bates & Rogers Constr. Co., 1405 Ellsworth Bldg. (Res., 320 Belden Ave.), Chicago, Ill.

Beahan, Willard	171 Oakdale St., Cleveland, Ohio.
Bell, James Richard	25 Victoria St., Westminster, London, S. W., England.
Bent, Cornelius Conway Felton	Care, Gen. Supt.'s Office, B. & O. R. R., Baltimore, Md.
Bergh, Louis DeCoppet	Archt., 189 Broadway, New York City.
Bienenfeld, Bernard	Cons. Engr., 1117 Kohl Bldg., San Francisco, Cal.
Carr, Albert	Mgr. of Constr., Mexican Light & Power Co., Necaxa, Distrito de Huauchinango, Puebla, Mexico (Res., 68 Carnegie Ave., East Orange, N. J.).
Darling, Fred Steere	Div. Engr. of Constr., C. P. Ry., 112 King St., West, Toronto, Ont., Canada.
Dunn, Daniel Burke	Div. Engr., Constr., Atlanta & Birmingham Air Line Ry., 129 Spring St., Atlanta, Ga.
Ellis, Samuel Clarence	P. O. Box 1439, Boston, Mass.
Fitch, Charles Hall	Superv. Engr., U. S. Geological Survey, P. O. Box 1716, Denver, Colo.
Frye, Albert Irvin	210 Hawthorne St., Cor. Rogers Ave., Brooklyn, N. Y.
Fuller, William Barnard	800 Westinghouse Bldg., Pittsburg, Pa.
Going, Alvah Seymour	Asst. Engr., Grand Trunk Pacific Ry., Edmonton, Alberta, Canada.
Green, Hubert Edward	Engr., U. S. Reclamation Service, Belle Fourche, S. Dak.
Kastl, Alexander Edward	Cons. Engr., Chillicothe, Ill.
Keller, Charles	Capt., Corps of Engrs., U. S. A., Care, Chf. of Engrs., War Dept., Washington, D. C.
Kennedy, William Harlin	400 Atlantic Ave., Pittsburg, Pa.
MacAllister, Dickinson	Fort Hunter P. O., Pa.
McDonald, William Naylor	Pres. and Gen. Mgr., The Granitoid Constr. Co., Nashville, Tenn.
Matthes, Gerard Hendrik	U. S. Reclamation Service, Phœnix, Ariz.
Opdyke, Stacy Brown, Jr	Contr. Engr., 341 West 23d St., New York City.

PALMER, JOHN ELDEN	(Gow & Palmer, Civ. Engrs. and Contrs.), 79 Milk St., Boston, Mass.
PUTNAM, GEORGE ROCKWELL	Director of Coast Surveys, Philippine Islands, Manila, Philippine Islands.
ROGERS, WALTER ALEXANDER	Vice-Pres., Bates & Rogers Constr. Co., 1405 Ellsworth Bldg., Chicago, Ill.
ROSS, ALEXANDER BELL	Representative, The Missouri Val. Bridge & Iron Co., Calle de Gante No. 2, City of Mexico, Mexico.
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Benton, Lewis Steuerwald	Office of Asst. Terminal Engr., N. Y. C. & H. R. R., Grand Central Station, New York City.
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RESIGNATIONS.

ASSOCIATE MEMBERS.

Date of Resignation.

Pincombe, William Edwin.............December 31st, 1904.

DEATHS.

de Funiak, Frederick..................Elected Member May 7th, 1873; died March 29th, 1905.

Hayes, Richard Somers................Elected Member September 6th, 1882; died March 2d, 1905.

Lederle, George Anthony.............Elected Member October 6th, 1886; died March 27th, 1905.

Marr, George Anson...................Elected Member October 3d, 1883; died March 24th, 1905.

MONTHLY LIST OF RECENT ENGINEERING ARTICLES OF INTEREST.

(March 5th, 1905, to April 8th, 1905.)

NOTE.—*This list is published for the purpose of placing before the members of the Society, the titles of current engineering articles, which can be referred to in any available engineering library, or can be procured by addressing the publication directly, the address and price being given wherever possible.*

LIST OF PUBLICATIONS.

In the subjoined list of articles references are given by the number prefixed to each journal in this list.

(1) *Journal,* Assoc. Eng. Soc., 257 South Fourth St., Philadelphia, Pa., 30c.
(2) *Proceedings,* Engrs. Club of Phila., 1122 Girard St., Philadelphia, Pa.
(3) *Journal,* Franklin Inst., Philadelphia, Pa., 50c.
(4) *Journal,* Western Soc. of Engrs., Monadnock Block, Chicago, Ill.
(5) *Transactions,* Can. Soc. C. E., Montreal, Que., Canada.
(6) *School of Mines Quarterly,* Columbia Univ., New York City, 50c.
(7) *Technology Quarterly,* Mass. Inst. Tech., Boston, Mass., 75c.
(8) *Stevens Institute Indicator,* Stevens Inst., Hoboken, N. J., 50c.
(9) *Engineering Magazine,* New York City, 25c.
(10) *Cassier's Magazine,* New York City, 25c.
(11) *Engineering* (London), W. H. Wiley, New York City, 25c.
(12) *The Engineer* (London), International News Co., New York City, 35c.
(13) *Engineering News,* New York City, 15c.
(14) *The Engineering Record,* New York City, 12c.
(15) *Railroad Gazette,* New York City, 10c.
(16) *Engineering and Mining Journal,* New York City, 15c.
(17) *Street Railway Journal,* New York City, 35c.
(18) *Railway and Engineering Review,* Chicago, Ill., 10c.
(19) *Scientific American Supplement,* New York City, 10c.
(20) *Iron Age,* New York City, 10c.
(21) *Railway Engineer,* London, England, 25c.
(22) *Iron and Coal Trades Review,* London, England, 25c.
(23) *Bulletin,* American Iron and Steel Assoc., Philadelphia, Pa.
(24) *American Gas Light Journal,* New York City, 10c.
(25) *American Engineer,* New York City, 20c.
(26) *Electrical Review,* London, England.
(27) *Electrical World and Engineer,* New York City, 10c.
(28) *Journal,* New England Water-Works Assoc., Boston, $1.
(29) *Journal,* Society of Arts, London, England, 15c.
(30) *Annales des Travaux Publics de Belgique,* Brussels, Belgium.
(31) *Annales de l'Assoc. des Ing. Sortis des Ecole Speciales de Gand.* Brussels, Belgium.
(32) *Memoires et Compte Rendu des Travaux,* Soc. Ing. Civ. de France, Paris, France.
(33) *Le Genie Civil,* Paris, France.
(34) *Portefouille Economique des Machines,* Paris, France.
(35) *Nouvelles Annales de la Construction,* Paris, France.
(36) *La Revue Technique,* Paris, France.
(37) *Review de Mecanique,* Paris, France.
(38) *Revue Generale des Chemins de Fer et des Tramways,* Paris, France.
(39) *Railway Master Mechanic,* Chicago, Ill., 10c.
(40) *Railway Age,* Chicago, Ill., 10c.
(41) *Modern Machinery,* Chicago, Ill., 10c.
(42) *Transactions,* Am. Inst. Elect. Engrs., New York City, 50c.
(43) *Annales des Ponts et Chaussees,* Paris, France.
(44) *Journal,* Military Service Institution, Governor's Island, New York Harbor, 50c.
(45) *Mines and Minerals,* Scranton, Pa., 20c.
(46) *Scientific American,* New York City, 8c.
(47) *Mechanical Engineer,* Manchester, England.
(48) *Zeitschrift,* Verein Deutscher Ingenieure, Berlin, Germany.
(49) *Zeitschrift für Bauwesen,* Berlin, Germany.
(50) *Stahl und Eisen,* Düsseldorf, Germany.
(51) *Deutsche Bauzeitung,* Berlin, Germany.
(52) *Rigasche Industrie-Zeitung,* Riga, Russia.
(53) *Zeitschrift,* Oesterreichischer Ingenieur und Architekten Verein, Vienna, Austria.
(54) *Transactions,* Am. Soc. C. E., New York City, $5.

(55) *Transactions*, Am. Soc. M. E., New York City, $10.
(56) *Transactions*, Am. Inst. Min. Engrs., New York City, $5.
(57) *Colliery Guardian*, London, England.
(58) *Proceedings*, Eng. Soc. W. Pa., 410 Penn Ave., Pittsburg, Pa., 50c.
(59) *Transactions*, Mining Inst. of Scotland, London and Newcastle-upon-Tyne, England.
(60) *Municipal Engineering*, Indianapolis, Ind., 25c.
(61) *Proceedings*, Western Railway Club, 225 Dearborn St., Chicago, Ill., 25c.
(62) *American Manufacturer and Iron World*, 59 Ninth St., Pittsburg, Pa.
(63) *Minutes of Proceedings*, Inst. C. E., London, England.
(64) *Power*, New York City, 20c.
(65) *Official Proceedings*, New York Railroad Club, Brooklyn, N. Y., 15c.
(66) *Journal of Gas Lighting*, London, England, 15c.
(67) *Cement and Engineering News*, Chicago, Ill., 25c.
(68) *Mining Journal*, London, England.
(69) *Mill Owners*, New York City, 10c.
(70) *Engineering Review*, New York City, 10c.
(71) *Journal*, Iron and Steel Inst., London, England.
(72) *Street Railway Review*, Chicago, 30c.
(73) *Electrician*, London, England, 18c.
(74) *Transactions*, Inst. of Min. and Metal., London, England.
(75) *Proceedings*, Inst. of Mech. Engrs., London, England.
(76) *Brick*, Chicago, 10c.
(77) *Journal*, Inst. Elec. Engrs., London, England.
(78) *Beton und Eisen*, Vienna, Austria.
(79) *Forscherarbeiten*, Vienna, Austria.
(80) *Tonindustrie-Zeitung*, Berlin, Germany.
(81) *Zeitschrift fur Architektur und Ingenieurwesen*, Wiesbaden, Germany.
(82) *Dinglers Polytechnisches Journal*, Berlin, Germany.

LIST OF ARTICLES.

Bridge.

Live Loads for Railroad Bridges.* Henry W. Hodge, M. Am. Soc. C. E. (54) Vol. 54, Pt. A.
Notes on Old Railway Bridges.* (21) Mar.
Methods of Expansion of Railway Bridges. Francis S. Rice. (58) Mar.
Cushioned Floor Beds for Railroad Bridges. E. K. Morse. (58) Mar.
The Monongahela River Suspension Bridge at Morgantown, W. Va.* W. H. Boughton. (13) Mar. 9.
Preparing Foundation-Beds for Short Railway Bridge Spans with Hand-Driven Sheet-Piling.* Walter N. Frickstad. (13) Mar. 9.
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Connecticut Avenue Bridge, Washington, D. C.* (40) Mar. 24.
Iron and Steel Structures.* (Abstract of Rept. presented before the Amer. Ry. Eng. and M. of W. Assoc.) (40) Mar. 24.
The Erection of the Moline Bridge.* (14) Mar. 25.
A Large Concrete Pier with a Sheet Pile and Canvas Cofferdam.* James C. Hain. (13) Mar. 30.
The New Blackwell's Island Bridge.* (46) Apr. 1.
The Reinforced Concrete Bridge at Kankakee. R. D. Gregg. (Paper read before the Illinois Soc. of Civil Engrs. and Surveyors.) (14) Apr. 1.
The General Design of the Quebec Bridge: The Structural Features of the Longest-Span Bridge Yet Undertaken. (14) Serial beginning Apr. 1.
Failure of a Bridge Pier on the Phœnix & Eastern R. R.* C. K. Conrad. (13) Apr. 6.
A Reinforced Concrete Foot-Bridge at Como Park, St. Paul, Minn.* (13) Apr. 6.
Le Problème des Forces Mobiles. Léon Descans. (30) Feb.

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Notice Explicative sur la Méthode suivie pour Réparer un Pont de 12 Mètres d Ouverture Dont une Culée avait Subi un Tassement après le Décintrement.* Jouvion. (36) Feb. 25.

Pont Suspendu de Jons-Niévroz sur le Rhone.* J. Dor. (33) Mar. 18.

Bruchbelastung einer Hennebique-Konstruktion und einer Eisenbeton-Brücke System "Möller." Hauf. (Paper read before the Deutsche Beton Verein.) (51) Serial beginning Mar. 22.

Electrical.

Hydrodynamical and Electromagnetic Investigations Regarding the Magnetic-Flux Distribution in Toothed-Core Armatures.* H. S. Hele-Shaw, Alfred Hay, M. Inst. E. E., and P. H. Powell. (77) Vol. 34, Pt. 1.

Studies in Magnetic Testing.* G. F. C. Searle. (77) Vol. 34, Pt. 1.

The Use of Iron in Alternate-Current Instruments.* W. E. Sumpner, M. Inst. E. E. (77) Vol. 34, Pt. 1.

On the Systems of Electric Units. Moise Ascoli. (Paper read before the International Elec. Cong.) (77) Vol. 34, Pt. 1.

The Absolute Value of the E. M. F. of the Clark and the Weston Cells. Henry S. Carhart and George W. Patterson. (Paper read before the International Elec. Cong.) (77) Vol. 34, Pt. 1.

The So-Called International Electrical Units. Frank A. Wolff. (Paper read before the International Elec. Cong.) (77) Vol. 34, Pt. 1.

An Electrical Review of the Louisiana Purchase Exposition of 1904.* R. Borlase Matthews, A. M. I. C. E. (26) Serial beginning Feb. 24.

An Ideal Switchboard Base.* Leonard J. Pumphrey. (26) Feb. 24.

Efficiency of Power Transmission and Storage. (12) Feb. 24.

Surface Condensing Plant Driven by Fynn Repulsion-Induction Motor.* (26) Feb. 24; (73) Feb. 24.

Telephone Line Engineering. C. J. H. Woodbury. (3) Mar.

An Amperemeter for High Potential Currents.* H. Clyde Snook. (3) Mar.

The Alternating Current Series Motor.* (F. D. Newbury. (Paper read before the Westinghouse Electric and Mfg. Co.) (39) Mar.

Suggestions Concerning Electrical Apparatus.* W. H. Wakeman. (64) Mar.

Application of Electricity to Industrial Purposes.* J. F. C. Snell. (Abstract of Paper read before the North East Coast Inst. of Engrs. and Shipbuilders.) (73) Mar. 3.

The Osmium Lamp.* Fritz Blau. (Abridged tr. of Paper read before the Elektrotechnischer Verein of Berlin.) (73) Mar. 3.

The Western Electric Co.'s Factory, North Woolwich.* (26) Mar. 3.

The Localisation of Faults on Cables. (26) Mar. 3.

An Italian Electrical Laboratory.* Guido Sernenza. (27) Mar. 4.

Test of Direct-Connected Generators.* George T. Hanchett. (27) Mar. 4.

The Meter-Testing Board of the Detroit Edison Company.* (27) Mar. 4.

Electrically-Driven Lathes at the Washington Navy Yard Gun Factory.* N. Monroe Hopkins. (27) Mar. 4.

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Electrical Equipment of Messrs. Harland & Wolff's Shipbuilding Works.* (73) Serial beginning Mar. 10.

A High or Low Temperature Alarm.* Horace Darwin. (11) Mar. 10.

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High-Tension Insulators.* E. H. Crapper. (11) Serial beginning Mar. 17.

Blast Furnace Gas Engines for Electric Power Generation.* (73) Mar. 17.

The Brush Electrical Engineering Company's "Falcon" Works.* (26) Serial beginning Mar. 17.

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The Application of Electricity to a Large Manufacturing Industry.* (27) Mar. 18.

An Induction-Motor Factory Installation.* (27) Mar. 18.

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Electric Motor Equipment of the Worthington Hydraulic Works.* (27) Mar. 18.

The Application of Electric Motors to Machine Tools. George T. Hanchett. (27) Mar. 18.

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Transportation of Materials by Electricity.* A. Frederick Collins. (46) Mar. 18.

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The Phœnix-Pohl Dynamos and Motors.* (12) Mar. 24; (26) Mar. 24.

25-Ton Electric Coaling Crane at Leith Harbour.* (22) Mar. 24.

Harmonic Analyzer.* George H. Rowe. (26) Mar. 25.

Some Tests of Tantalum Lamps.* A. E. Kennelly and S. E. Whiting. (26) Mar. 25.

Some Departures in Design in a Detroit Central Power Station. (14) Mar. 25.

Electric Power Transmission in the Missouri Lead Mining District.* (13) Mar. 30.

Electricity from Water Power Versus Gas. Alton D. Adams. (10) Apr.

Shipyard Cranes and Their Functions in Marine Construction.* Jos. S. Shultz. (9) Apr.

The Erection of Alternating-Current Machines.* (64) Apr.

Principles and Applications of Mercury Vapor Apparatus. F. Von Keller. (2) Apr.

The Meter Department of the New York Edison Company.* (27) Apr. 1.

Electric Power for Refrigeration.* J. C. Chamberlain. (27) Apr. 1.

Brush Core-Type Transformer.* (27) Apr. 1.

Single-Phase Motors for Elevator, Hoist and Traveling Crane Service.* (27) Apr. 1.

Cooper Hewitt Mercury Vapor Converter.* (27) Apr. 1.

Electromagnetic Clutch.* (27) Apr. 1.

Automatic Motor Starters.* (27) Apr. 1.

Oil-Film Receiver for Space Telegraphy.* (From *Western Electrician.*) (19) Apr. 1.

An Automatic Electric Welding Machine.* Emile Guarini. (20) Apr. 6.

The Construction of a Four-Inch Spark Induction Coil.* Thomas R. Hopper. (19) Apr. 8.

Les Forces Motrices des Lacs de Joux et de l'Orbe (Suisse).* C. H. Perrin. (33) Serial beginning Feb. 25.

Hydromechanische Einrichtungen von Neueren Österreichischen Elektrizitätswerken.* Gustav Witz. (53) Feb. 24.

Über die Akustik von Hörsälen und ein Instrument, Sie zu Bestimmen.* Sigm. Exner. (53) Mar. 10.

Der Elektrische Kohlelichtbogen im Vakuum. A. Hoerburger. (82) Serial beginning Mar. 25.

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The French Armoured Cruiser *Ernest Renan.** (12) Mar. 3.

The Triple-Screw Turbine-Driven Cunard Liner *Carmania.* (11) Mar. 3.

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The Relation of Depth of Water to Speed and Power of Ships.* (13) Mar. 16.

A General Discussion of Resistance and Power Consumption of Ships in Different Depths of Water.* D. W. Taylor. (13) Mar. 16.

The 10 000-Ton Lake Vessels.* (20) Mar. 16.

Admiral Fleuriais's Gyroscopic Horizon.* (11) Mar. 17.

Scouts (in the Modern Navy). (12) Mar. 17.

The Development of Torpedo-Boat Destroyers. W. J. Harding. (Abstract of Paper read before the Institute of Marine Engrs.) (12) Mar. 17.

Steam Trials of H. M. S. *Carnarvon.** (11) Mar. 17.

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Efficiency of Power Transmission and Storage. (12) Feb. 24.

Tests of Tools of High-Speed Steel.* (12) Feb. 24.

Automatic Hoist.* (11) Feb. 24.

Universal Woodworking Machine.* (11) Feb. 24.

The Lubrication of Steam Engines and Machinery. (47) Serial beginning Feb. 25.

A Gauge for Measuring the Depth of Fluid in Tanks.* (47) Serial beginning Feb. 25.

Machine Tool Calculations. Thomas R. Shaw. (47) Serial beginning Feb. 25.

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AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PAPERS AND DISCUSSIONS.

This Society is not responsible, as a body, for the facts and opinions advanced in any of its publications.

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AMERICAN SOCIETY OF CIVIL ENGINEERS.

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PAPERS AND DISCUSSIONS.

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ROUND-HOUSE FRAMING.

By R. D. Coombs, Assoc. M. Am. Soc. C. E.

To be Presented May 3d, 1905.

It is not claimed by the writer that the following designs and outlines of specifications for round-houses are entirely new, but, by bringing before the Society what he considers desirable construction, it is hoped that the discussion may be of benefit in future work.

The writer recognises certain apparent inconsistencies: For instance, in the concrete-steel design (Plate XXVIII), there is shown a wooden monitor. This might more appropriately be made of fireproof materials. However, the greater distance from the floor raises the question whether or not such additional expense is warranted. It might be added that the monitor shown should be dowelled or otherwise fastened to the sill girder. The cast-iron door posts, of course, may be made of structural steel design.

The use of cast-iron door posts is justifiable. They can be made economically of greater thickness, and thus be less affected by corrosion. The brittleness of cast iron occasionally seems to be an

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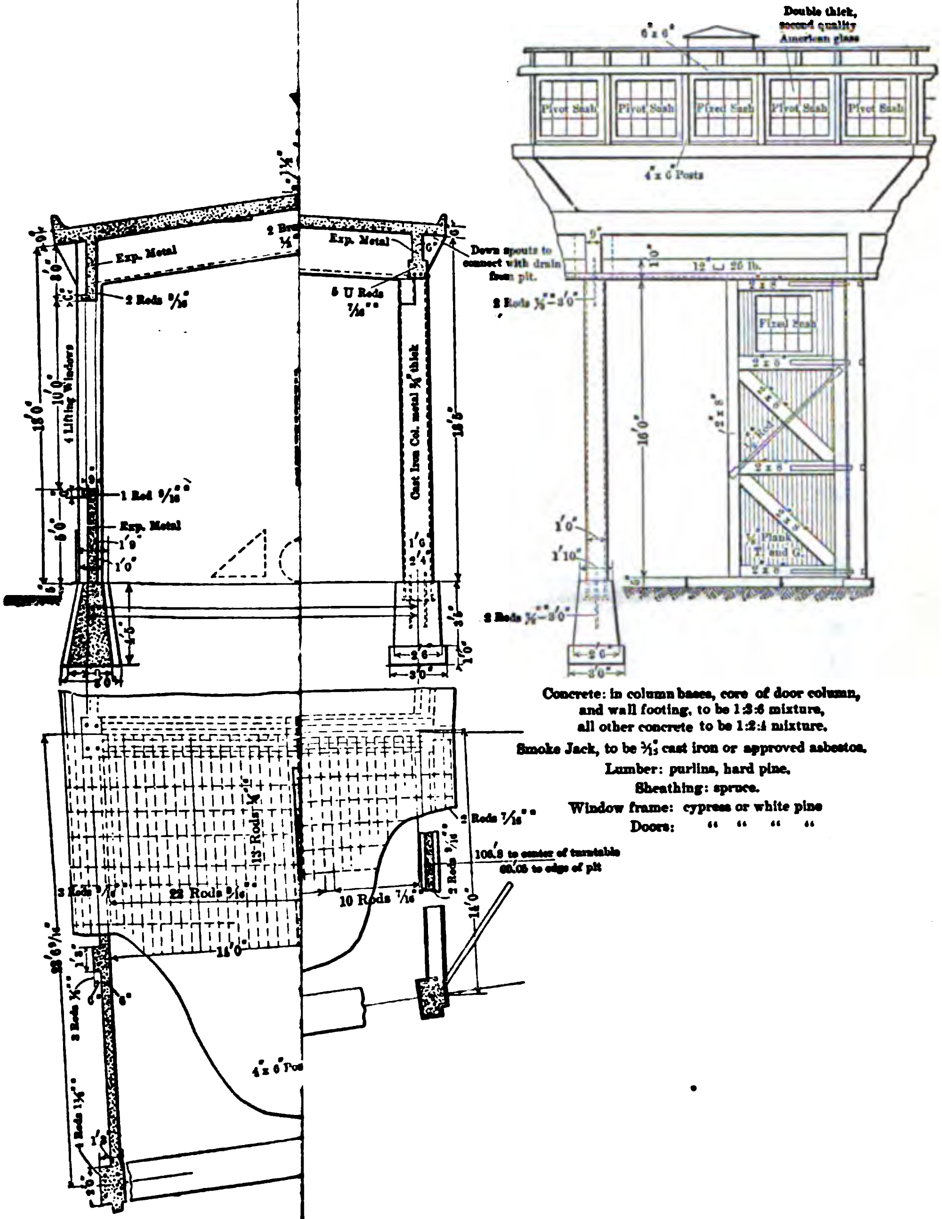
Note.—These papers are issued before the date set for presentation and discussion. Correspondence is invited from those who cannot be present at the meeting, and may be sent by mail to the Secretary. Discussion, either oral or written, will be published in a subsequent number of *Proceedings*, and, when finally closed, the papers, with discussion in full, will be published in *Transactions*.

PLATE XXVIII.
PAPERS, AM. SOC. C. E.
APRIL, 1905.
COOMBS ON
ROUND-HOUSES.



Concrete: in column bases, core of door column, and wall footing, to be 1:3:6 mixture, all other concrete to be 1:2:4 mixture.

Smoke Jack, to be ⅜" cast iron or approved asbestos.

Lumber: purlins, hard pine.

Sheathing: spruce.

Window frame: cypress or white pine

Doors: " " " "

actual advantage. An engine recently jumped the track on leaving the turntable, and carried away the cast-iron door post. Although the brick arches fell, the roof merely sagged somewhat, cracking along the lines of the adjacent bays. Had the post been of structural material, particularly if connected with the truss, the two bays of the roof would undoubtedly have been pulled down. Wooden doors seem to the writer to be preferable, both on account of cost and resistance to corrosion, when compared with steel doors of either the rolling or ordinary type. Lifting wooden doors, in themselves, are a neater looking contrivance than the old swinging type, and should be subject to fewer collisions. They are more likely to get out of order from minor accidents, however, and require a greater height of building at the interior wall. Within limits, the entrance doors should be of ample width, as they are likely to be injured either by a blow from a damaged cab, or on account of carelessness in fastening.

Apart from the question of fire, wooden round-houses would seem to have an advantage in cost and life over anything except a protected or concrete-steel design. The question of fire may be a very serious one, but appears to be over-rated. Proper pipe connections, in cases where the house is constantly in use, should greatly reduce this danger. As will be noted by an examination of the different designs, light and ventilation have been made important factors. In these days a good working light is rightly regarded as of great importance in all shops. Better results from labor, ease of inspection—indeed, less need of inspection—and a superior condition of cleanliness and order, are directly traceable to proper lighting. As a round-house is one of the places peculiarly in need of ventilation, a generous supply of smoke exits is true economy. Any corners in the roof, or purlins running across the slope and thus acting as baffles to the smoke, are very undesirable. The designs shown have been made to eliminate this trouble as far as possible. In the old-fashioned round-houses it is frequently almost impossible to see the roof sheathing on account of the smoke. The condition of light riveted-iron trusses in such an atmosphere should not need demonstration. Under such circumstances, from ten to fifteen years is probably the maximum life of the roof. The writer knows of several cases where trusses under similar conditions were literally falling to pieces at the end of that period. If steel is to be used, beam sections having a greater thickness of material than the small angles frequently used, and which are more readily painted and inspected, should be used in the design. In any case, periodical inspection and painting are absolutely necessary.

Smoke-jacks have been constructed of a variety of materials. Wood, cast iron, tile and asbestos have given satisfactory results. Smoke-jacks of thin, rolled plate have a very short life, and, in the writer's estimation, are not worth installing. Wood lasts rather better than might be expected, and, in connection with a fire-proof roof, should prove economical and safe. It is not necessary to sand the interior, though the exterior should be well painted.

Cast iron, if heavy, has a fair length of service. Tile is more expensive, and its weight and liability to break, if detachable, are objectionable features. Asbestos is light in weight and is fireproof, but is more expensive in first cost.

The smoke-jacks shown on the drawings are not intended to represent any particular type. A telescoping jack, provided with a bell having a diameter of about 4 ft., would be the writer's preference.

Gutters and down-spouts, while necessary in some localities, are often omitted. In any case, thin metal should not be used, as corrosion marks them for an early grave. In cold climates the downspouts may advantageously be carried down inside the house to connect with the pit drainage system.

In designing a reinforced concrete roof, the question arises, will the gases penetrate hair cracks, and attack the metal? Such cracks, though invisible, will probably be present in any design, unless it is abnormally heavy. The writer is of the opinion that no failure need be apprehended from this cause.

Certain of the large roads are now building round-houses, arranged to serve partly as shops, by installing overhead cranes and hoists. It is suggested that a portable gantry crane might be used in houses where it is not desirable to incur the expense of a regular overhead installation.

The writer submits Plate XXVIII as a suggestion for a steel, expanded metal, and concrete design.

The unit prices given in the following tables will vary, of course,

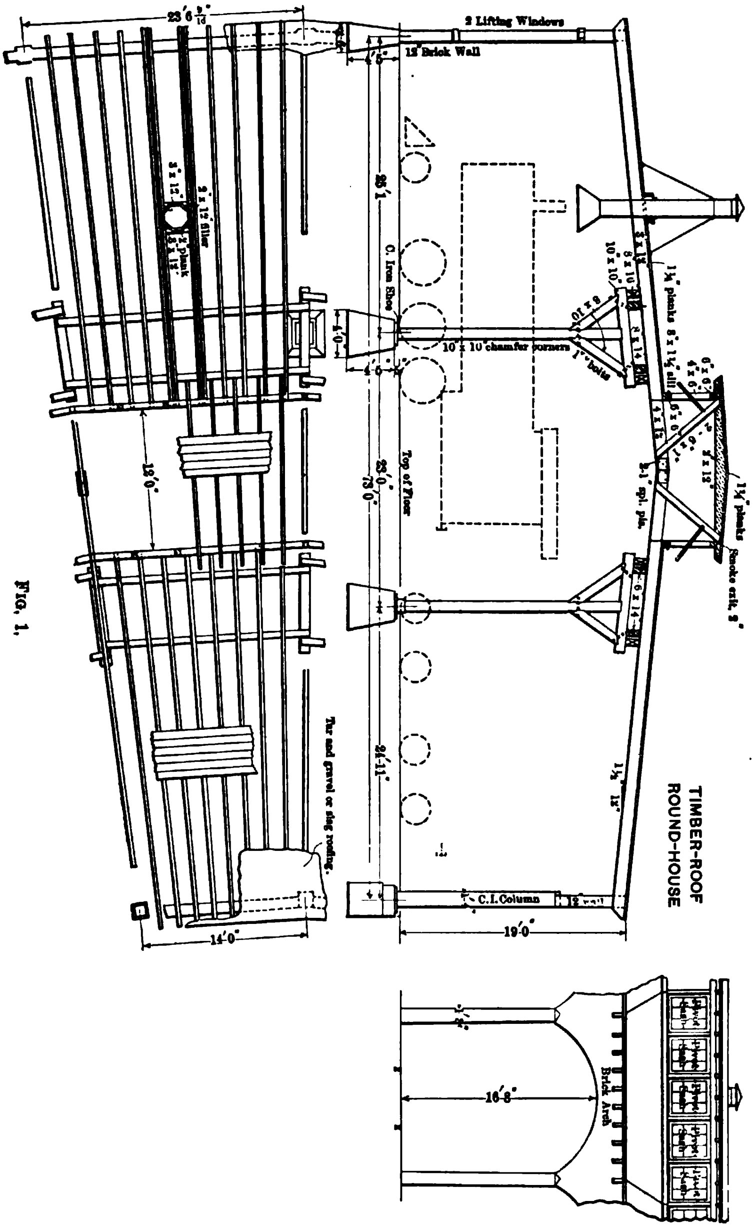


FIG. 1.

TIMBER-ROOF ROUND-HOUSE

in different localities and at different times. Such differences in cost, combined with local conditions, might render one of the more expensive designs in reality economical.

The loading and stress limits used are given in Table 1.

TABLE 1.—Loads and Units.

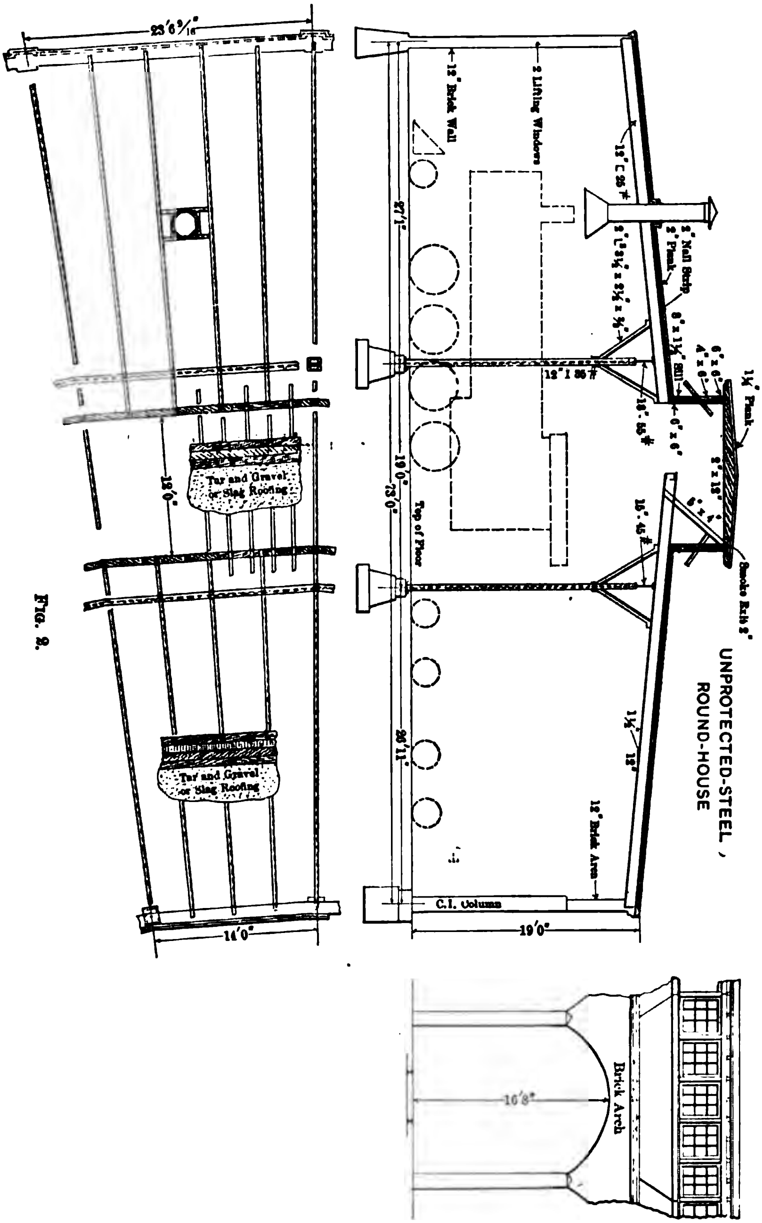
Dead load = Weight of material.
Wind and snow = 25 lb. per sq. ft.
Wind and snow = 30 lb. per sq. ft. (concrete-steel design).

Unit stresses.	Wood design......	Purlins..........	900 lb.	
		Girders..........	1 200 "	
	Steel design.........	Purlins..........	10 000 "	
		Girder	9 000 "	(longer).
		Girder	9 700 "	(shorter).
	Concrete-steel design..............	Steel	16 000 "	
		Concrete........	800 "	(1 month).

TABLE 2.—Quantities for Round-House of Wooden Design. One Bay. Fig. 1.

Items.	Quantities.		Prices.	Amounts.	Totals.
Roof and Center Columns.					
Monitor sheathing (spruce)......	380	ft., B. M.	$35.00	$13.30	
Monitor purlins (pine)...........	320	" "	40.00	12.80	
Monitor framing (cypress)......	345	" "	60.00	20.70	
Roof sheathing (spruce).........	1 512	" "	35.00	52.92	
Roof purlins (pine)...............	2 238	" "	40.00	89.52	
Girders (pine)....................	675	" "	40.00	27.00	
Columns and caps (pine).........	601	" "	40.00	24.04	
Framing, bridging, etc. (spruce).	65	" "	40.00	2.60	
Bolts	70	lb.	0.03	2.10	
Pivot windows (3 ft. 6 in. × 3 ft. 7 in.)........................	4		4.00	16.00	
Pivot windows (3 ft. 6 in. × 3 ft. 3 in.)........................	4		4.00	16.00	
Fixed windows (3 ft. 6 in. × 3 ft. 3 in.)........................	2		2.50	5.00	
Column foundations (concrete)..	2.93	cu. yd.	6.00	17.58	
Roofing..........................	1 513	sq. ft.	0.04	60.52	
Smoke-jack......................	....	....	....	30.00	
Painting	4 200	sq. ft.	0.0225	94.50	
Cast-iron column base............	700	lb.	0.0275	19.25	
					$504.77
Walls.					
Brick wall.......................	12.5	cu. yd.	$6.50	$81.25	
Brick arch.......................	1.8	" "	8.00	14.40	
Cast-iron column............	3 200	lb.	0.0275	88.00	
Wall foundation..................	7.2	cu. yd.	6.00	43.20	
Post foundation............... ...	1.46	" "	6.00	8.76	
Lifting windows (4 ft. 6 in. × 9 ft. 6 in.).	2		10.00	20.00	
Window framing (cypress).......	200	ft., B. M.	60.00	12.00	
Double door......................	....	....	....	50.00	
					317.61
Total..................	....	....	....	....	$822.38

Painting of sash and door included in cost of same.



UNPROTECTED-STEEL ROUND-HOUSE

FIG. 2.

TABLE 3.—QUANTITIES FOR ROUND-HOUSE OF STEEL DESIGN. ONE BAY. FIG. 2.

Items.	Quantities.	Prices.	Amounts.	Totals.
Roof and Center Columns.				
Monitor sheathing (spruce)	380 ft., B. M.	$35.00	$13.30	
Monitor purlins (pine)	330 " "	40.00	13.20	
Monitor framing (cypress)	345 " "	60.00	20.70	
Roof sheathing (spruce)	2 330 " "	35.00	81.55	
Nailing strips (spruce)	135 " "	40.00	5.40	
Steel columns 1 550 lb. Purlins 7 600 " Girders 1 900 " Knees, etc 450 " Bolts and fillers 100 "	11 600 lb.	0.03	348.00	
Pivot windows (3 ft. 6 in. × 3 ft. 7 in.)	4	4.00	16.00	
Pivot windows (3 ft. 6 in. × 3 ft. 3 in.)	4	4.00	16.00	
Fixed windows (3 ft. 6 in. × 3 ft. 3 in.)	2	2.50	5.00	
Column foundations. Concrete	2.26 cu. yd.	6.00	13.56	
Cap	0.14 " "	10.00	1.40	
Roofing	1 470 sq. ft.	0.04	58.80	
Smoke-jack			30.00	
Painting. Steel	1 250 sq. ft.	0.01	12.50	
Wood	1 900 " "	0.0225	42.75	
				$677.76
Walls.				
Brick wall	12.5 cu. yd.	$6.50	$81.25	
Brick arch	1.8 " "	8.00	14.40	
Cast-iron columns	3 100 lb.	0.0275	85.25	
Wall foundation	7.2 cu. yd.	6.00	43.20	
Post. Concrete	1.0 " "	6.00	6.00	
Cap	0.25 " "	10.00	2.50	
Lifting windows (4 ft. 6 in. × 9 ft. 6 in.)	2	10.00	20.00	
Window framing (cypress)	200 ft., B. M.	60.00	12.00	
Double door			50.00	
				314.60
Total				$992.36

SPECIFICATIONS FOR ROUND-HOUSE OF WOODEN DESIGN.

Foundation.—The foundation shall be of concrete masonry and brick, to suit local conditions.

Brick Walls.—The brick shall be good, sound, hard-burned brick, well laid and bonded. The mortar shall be of Portland cement and sand in the proportions of 1 to 2.

Lumber.—All lumber shall be of the best quality, thoroughly seasoned and surfaced on all sides.

Sheathing	Matched spruce.
Cross-bridging	Spruce.
Window framing	Cypress or white pine.
Sash	" " " "
Doors	" " " "
All other lumber	Long-leaf hard pine.

TABLE 4.—QUANTITIES FOR ROUND-HOUSE OF CONCRETE-STEEL DESIGN. ONE BAY. PLATE XXVIII.

Items.	Quantities.	Prices.	Amounts.	Totals.
Roof and Center Columns.				
Rods	3 770 lb.	$0.03	$113.10	
Concrete (superstructure)	42.59 cu. yd.	15.00	638.88	
Concrete (column bases)	2.3 " "	6.00	13.80	
Monitor purlins (pine)	410 ft., B. M.	40.00	16.40	
Monitor sheathing (spruce)	420 " "	35.00	14.70	
Monitor frame (cypress)	280 " "	60.00	16.80	
Pivot windows (3 ft. 6 in. × 3 ft. 8 in.)		4.00	16.00	
Pivot windows (3 ft. 6 in. × 4 ft. 0 in.)		4.00	16.00	
Fixed windows (3 ft. 6 in. × 4 ft. 0 in.)		2.50	5.00	
Roofing	1 440 sq. ft.	0.04	57.60	
Gutter	38 lin. ft.	0.16	6.08	
Down-spout	18 " "	0.30	5.40	
Smoke-jack			30.00	
Painting	700 sq. ft.	0.0225	15.75	$965.51
Walls.				
Rods	640 lb.	$0.03	$19.20	
Channels	350 "	0.03	10.50	
Cast-iron column	2 330 "	0.0275	64.07	
Expanded metal (No. 10—6-in. mesh)	215 sq. ft.	0.027	5.80	
Concrete (superstructure)	642 cu. yd.	15.00	96.30	
Concrete (foundations)	7.09 " "	6.00	46.98	
Concrete (core of door post)	0.74 " "			
Lifting windows (4 ft. 6 in. × 9 ft. 6 in.)		10.00	40.00	
Window frame (cypress)	400 ft., B. M.	60.00	24.00	
Double door (12 ft. 8 in × 16 ft.)			40.00	
				346.85
Total				$1 312.36

Lintels and Caps.—Lintels and sills for wall windows, and cap stones for columns and door posts shall be of granite (or other suitable stone found in the locality), dressed even, and all exposed surfaces shall be six-cut.

Windows.—The windows shall have box frames. Both sashes shall be hung with best flax sash-cord, steel axle pulleys and iron counterweights; and shall be provided with strong sash locks. The glass shall be of second-quality, double-thick, American, thoroughly bedded, bradded and back-puttied. The pivot windows shall be provided with suitable stops, steel axles and approved operating device, and shall operate from the floor of the house.

Doors.—Each half door shall have four wrought-iron hinges, and one bolt and chain to the pair; door-stop and drop-bolt at the bottom properly fastened to the floor; and strong thumb-latch. A latching post shall be set in front of each door post, and suitable heavy hooks provided to hold the doors open. Certain specified doors shall have small entrance doors opening outward.

Paint.—All nail and screw heads shall be punched and puttied before painting, and all bolt-head countersinks shall be swabbed with tar. All woodwork shall receive two good coats of white lead and oil.

Roofing.—The roofing shall be of three thicknesses of tarred felt, laid over resin-sized sheathing paper, and covered with a uniform thickness of pitch and slag.

SPECIFICATIONS FOR ROUND-HOUSE OF CONCRETE-STEEL DESIGN.

Steel.—The steel shall be open-hearth.

Ultimate tension	62 000 to 68 000 lb.
Elastic limit	55% of ultimate.
Elongation	22% in 8 in.
Sulphur	0.05 per cent.
Phosphorus	0.06 " " (Acid.)
Phosphorus	0.04 " " (Basic.)

The steel shall be free from oil, dirt and rust. Care shall be taken to obtain a good contact between the steel and the concrete; and the position of the rods, as shown on the drawings, shall be carefully maintained. The coarser material in the concrete shall be excluded from under the rods.

Concrete.—The concrete shall be mixed in the following proportions: 1 part of Portland cement, 2 parts of sand and 4 parts of stone.

Cement.—******, or other approved brand of Portland cement shall be used.

Fineness: Residue by weight on No. 100 sieve, not more than 5 per cent.
Residue by weight on No. 200 sieve, not more than 25 per cent.

Initial set: Not less than 30 minutes.

Tensile strength of 1 sq. in., neat:

1 day	200 to 300 lb.
7 days	500 to 600 "
28 "	600 to 700 "

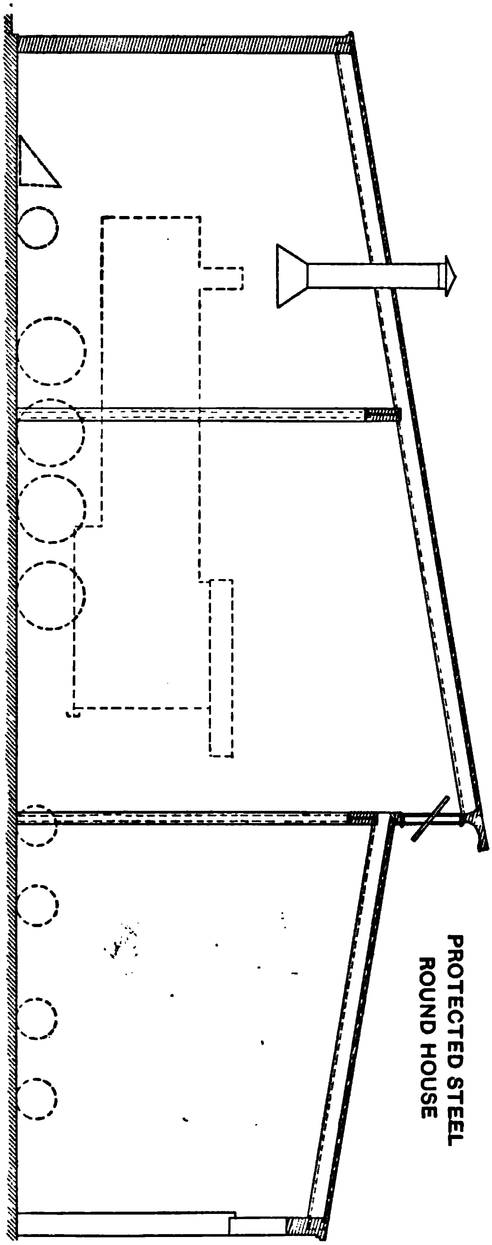


Fig. 8.

PROTECTED STEEL
ROUND HOUSE

The cement, otherwise, shall be in conformity with the specifications, for Portland cement, of the American Society for Testing Materials. The tests will be made in conformity with the standards recommended by the Special Committee on Uniform Tests of Cement, of this Society.

Sand.—The sand shall be clean, coarse and sharp, and free from silt or loam.

Stone.—All stone shall be hard, sound limestone, free from dirt or dust. In the superstructure no stone shall be more than ¾ in. in any dimension; and, in the foundation, no stone shall be more than 2½ in. in any dimension.

Mixing.—The concrete shall be thoroughly mixed in the specified proportions immediately before using, and any which has begun to set shall not be used. The stone shall be thoroughly wetted before mixing. The sand and cement shall be well mixed before adding the stone and water, and the whole shall be mixed again until the stone is thoroughly coated. The consistency of the concrete shall be such that water rises to the surface without ramming, and the mass "quakes" when additional quantities are thrown in.

Forms.—The supporting forms shall be practically unyielding under loads or ramming. Facing planks shall be dressed on one side and two edges, and closely jointed. The forms shall be left in place for four weeks, and after removal the exposed surfaces of the structure shall be rubbed down or trowelled with cement mortar to remove irregularities. The lagging shall be sprinkled at intervals to prevent shrinkage.

Laying Concrete.—The concrete shall be laid in 6-in. layers (except as hereinafter specified), and rammed. The coarser material shall be worked back from the forms so as to bring an excess of mortar to the face. Each column, girder, sill and lintel shall be laid continuously, *i. e.*, on each of these, work shall not be stopped until it is completed. The roof slabs shall be laid in one layer and continuously from girder to girder. On laying new work adjoining that which has already set, the latter shall be cleaned and wetted and cement mortar placed between. To join girders on walls already set with roof slabs, they shall be left rough to form a bond with the slabs. No concrete in the superstructure shall be laid in freezing weather. Finished surfaces shall be sprinkled daily for a week, and kept covered with straw or canvas for three weeks. Completed portions shall not be loaded with materials or used as walks.

Expansion.—Over every fourth girder there shall be a halved joint in the roof slab, separated by two thicknesses of heavy roofing felt.

Roofing.—The surface of the roof shall be well swabbed with coal-tar pitch, and covered with three layers of roofing felt laid with overlapping joints. Each layer shall be swabbed with pitch, and over the top surface thus made there shall be spread a uniform coating of pitch and slag (or gravel).

SPECIFICATION FOR CONCRETE FLOOR.

After excavating to the required depth, the subsoil shall be thoroughly compacted with heavy rammers. On this surface 4 in. of 1 : 3 : 6 concrete shall be laid and also an additional 2 in. of wearing surface composed of 1 : 2 : 4 concrete, finished with a 1 to 1 Portland cement and sand surface. These layers shall be laid as one layer and given a 2-in. crown between the pits.

SPECIFICATION FOR BRICK FLOOR.

After excavating to the required depth, the subsoil shall be thoroughly compacted with heavy rammers to a practically level surface. On this shall be laid a 4-in. bed of good "dead end" cinders, rolled with a roller weighing not less than one ton. Above this shall be placed 2 in. of sand thoroughly rolled. On this surface, which shall be given a 2-in. crown between the pits, shall be laid the brick floor. The brick shall be the best quality of hard-burned, machine-pressed, paving brick, laid closely together, on edge, breaking joints.

The floor shall be given a final rolling to an even surface, and the joints shall be filled with 1 to 1 Portland cement mortar.

Vol. XXXI. APRIL, 1905. No. 4.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PAPERS AND DISCUSSIONS.

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A FEW REMARKS ON FOUNDATIONS.

By L. L. Buck, M. Am. Soc. C. E.

To be Presented May 3d, 1905.

In studying foundations for heavy concentrated loads, the writer has observed the effects of such loads upon existing structures. In such cases, where defects soon appeared, one could easily trace their causes. Where such defects arise from the use of poor stone or mortar, they are not worth considering; but there are many cases, where such defects appear, in which both stone and mortar seem to be excellent. In such cases it is evident that the question of distribution must be examined.

Sometimes a heavy and heavily loaded column is found resting on a foot-box made up of plates riveted to the bottom of the columns with angles riveted to the lower edges of these plates, and then a horizontal plate having an area of seven or eight times the area of the cross-section of the column, and supposed to distribute the pressure over the area covered by the plate. This is an extreme case, and does not occur as often of late years as it did earlier; but there have been cases, within a few years, where a heavily

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loaded column rested on a casting so shallow that it could not nearly distribute its load over the whole area of the base of the casting.

The writer has in mind one case in which a heavy column rested on a casting, and the casting rested on a large nest of rollers. The outer ends of all the rollers and the outer rollers at each end of the bed were not borne upon at all. It is not easy to distribute enormous concentration of weight over a sufficiently large area to give the proper unit pressure over the whole area; but this should be done, and it requires greater height in proportion to the base of the bed than is in many cases given.

Having properly proportioned the foot of the column, attention must next be given to the masonry pedestal on which it is to rest. Supposing the bed-plate to distribute practically its whole load over its entire area equally. The question will arise as to how far outside of the bed-plate the stone of the pedestal can project (not only advantageously, but with safety), in the top course, below the coping, and how far it can go without absolute detriment to the work. If it is extended more than about 2 in. per foot of thickness of the course, no perceptible advantage will be gained. Of course, it must project sufficiently to keep the pressure per square foot within proper limits, including the weight of the masonry, and the wind pressure, and, if it is to rest on concrete, to keep the pressure on the concrete within proper limits.

The difficulty, with trying to extend the masonry too far beyond the bed-plate, is that the stone may crack, and, if so, it will start under the edge of the bed-plate, and the crack may incline still further under the bed-plate at the bottom of the course. Moreover, with too large a mass of masonry, there is a tendency to put the best masonry outside, and a poorer quality within. In this case the poorest masonry sustains the load. This is similar to making the pedestal of a bag filled with sand. In this case the bag will be pretty sure to burst, whether made of cloth or masonry.

Fig. 1 represents two courses made of cut stone, with ½-in. joints. This form secures excellent bond, and from it the writer has obtained excellent results.

Where four or more heavily laden columns rest on one foundation, the writer thinks it is best to have the center of pressure on

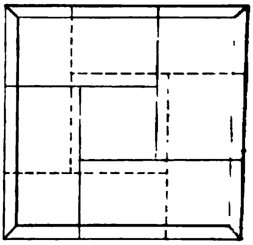

FIG. 1.

each column so nearly placed that the distance between each pair of columns, each way, shall be about equal to the sum of the distances of the extension of the masonry outside of the columns, and then build the pier in such a manner that there shall be a pedestal of first-class masonry under each column, similar to that of the single-column foundation. But the pedestals must be bonded to whatever masonry is outside of or between these pedestals.

In some cases, where the load on one column is very great, a casting, in order to distribute its load properly over the whole area of its base, must either be as high as the length of the base, or the casting must be in several pieces bolted together for convenience in handling. In this case the bottom length of the column can be given such a taper that its lower end will cover a space equal to half the area of the base of the casting, when the casting will require only about half the height required in the other case. Of course, the casting, in both cases, must be thoroughly ribbed. There are other ways of accomplishing this result, but it is doubtful if, on the score of economy, there are any better.

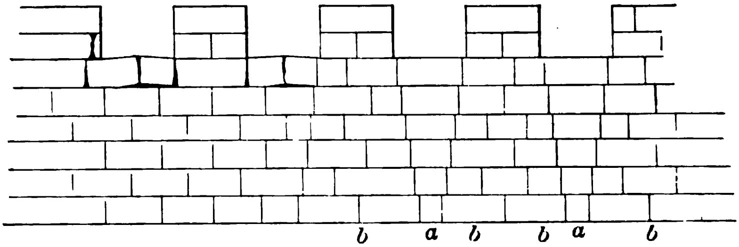

FIG. 2.

In the case of heavy walls having frequent window openings, one will sometimes find them showing disagreeable cracks, similar to those indicated in Fig. 2.

This trouble might have been avoided by a form of construction similar to the right-hand portion of the diagram. Construct the area of *b* so that the area of its base, in proportion to that of *a* shall be equal to that of the weights they respectively sustain.

The whole idea is to use the pedestal form, and not to project the stones under the heavily loaded portions more than the transverse strength of the stone will safely sustain.

Vol. XXXI. APRIL, 1905. No. 4.

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THE IRRIGATION SYSTEM OF ONTARIO, CALIFORNIA—ITS DEVELOPMENT AND COST.

By F. E. Trask, M. Am. Soc. C. E.

To be Presented May 17th, 1905.

This paper treats of the development and present status of an irrigation plant in the "Orange Belt" of Southern California, and gives the details and cost of a system which has been designed to meet exacting demands for "high duty and maximum utility." The results accomplished have been so satisfactory and pronounced that the United State Geological Survey projected this system in detail upon a relief map, for the purpose of exhibition at the St. Louis Fair; and the writer presents a photograph (Plate XXIX) of the model, in lieu of a map of the tract described in this paper, believing that it better portrays the controlling conditions in the development of this system.

The highest point shown on the relief map is Mount San Antonio, with an elevation of 10 080 ft., the south side of which is in the catchment area of the San Antonio Cañon. This cañon has an

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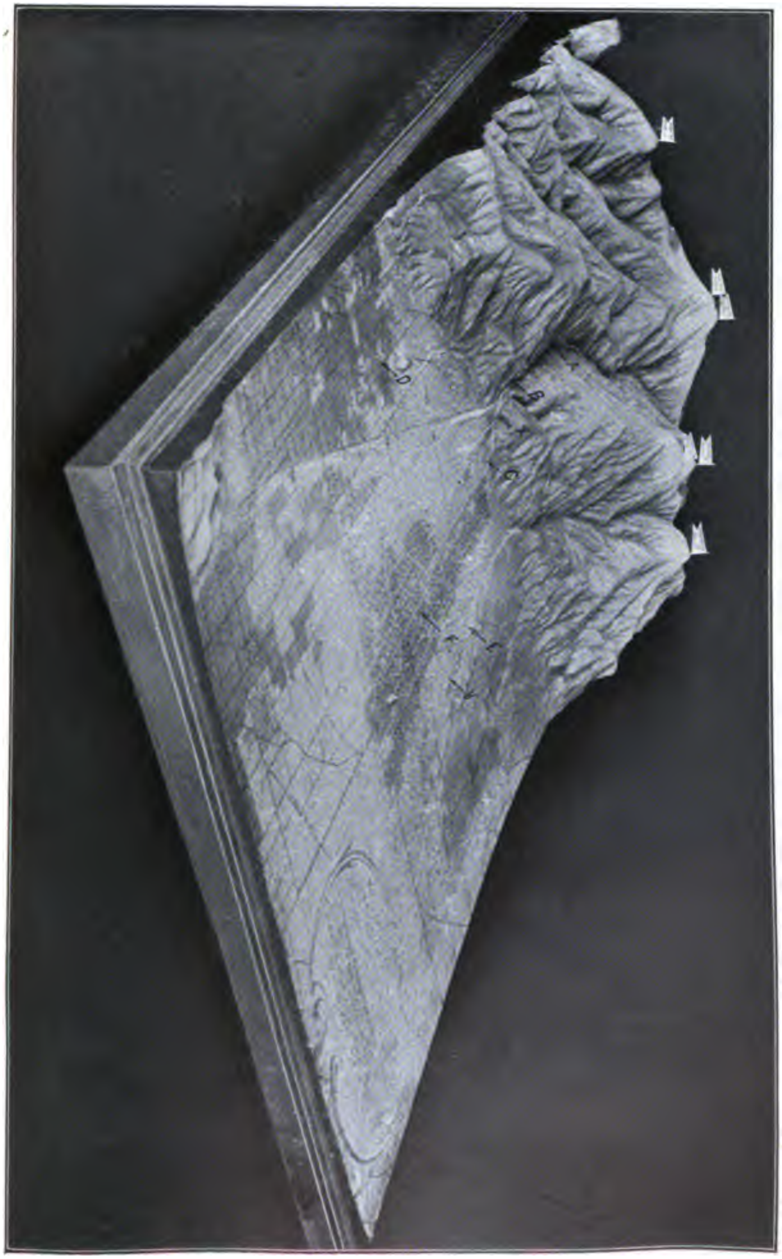

RELIEF MODEL OF ONTARIO, CAL.

area of about 23 sq. miles, with an elevation of 2 200 ft. at the mouth, where it debouches upon the plain. From the mountains the plain slopes to the south, and, at the lower limit of the colony, 8 miles from the cañon, has an elevation of 800 ft. The precipitous character of the San Antonio Cañon, together with its water supply, have made the development and use of water power an important adjunct and factor in the design and consummation of this irrigation system.

On Plate XXIX the points, *A, B* and *C,* show the locations of Power Plants Nos. 1, 3 and 2, respectively; *D* and *E* indicate the locations of underground water supplies which are pumped from gravel beds; *F* marks the position of the lighting sub-station; and *x* and *y* represent the locations of the San Antonio and Cucamonga tunnel developments, respectively.

Location.—The Town of Ontario is located in San Bernardino County, California, 39 miles east of the City of Los Angeles, and 19 miles west of the county seat. It extends from the Sierra Madre Mountains on the north, from 7 to 8 miles southward, and has an average width of about 3 miles, with a population of 4 000. The colony was surveyed and opened to settlement in 1883, and its principal industry, to which it owes its development and present success, is the production of citrus fruits. Just as good soils are to be found both east and west, but, without the water supply, which originally consisted of one source, the San Antonio Cañon, the place would not now exist.

Control and Management.—The ownership of the system, from its inception, has been in the San Antonio Water Company, a corporation; and, excepting the initial work, it has been constructed, extended and developed by this company to meet the present exacting requirements of the stockholders. The San Antonio Water Company is a mutual company, one of the first organized in California, and, as such, has been an object lesson and pattern to which more recent communities have looked, and from the experience of which they have profited. Its stock is owned by the owners of the realty. It has no right to supply other than its stockholders, and its business is conducted solely for them, there being no dividends or other profits accruing to the stockholders except such profit as they realize from the use of the water on their lands.

In 1902 it became necessary to acquire additional lands and water rights and to construct an electric plant. For this purpose a subsidiary company was formed, *viz.*, the Ontario Power Company, the stock of which is held by the San Antonio Water Company. In this paper, however, the writer will speak of the entire enterprise as the property of the latter company.

Water Supply.—The original supply was by gravity, being one-half the discharge from San Antonio Cañon. This was first increased by tunnel developments, and lastly by pumping from artesian sources and saturated gravel beds. A twenty-year July average gives about 700 miners' in. as the mean run-off from this cañon. The Ontario miners' inch represents $\frac{1}{50}$ cu. ft. per second—continuous flow—and the average duty of this water is 1 in. to 7 acres.

In the early days of the colony, the promoters discovered that there would be insufficient surface water from the San Antonio Cañon to supply all the requirements of their enterprise, and began the construction of what they claimed would be a bed-rock tunnel under the wash of the San Antonio Cañon at or near its mouth. This tunnel has a cross-section of about 3½ by 6½ ft. and a length of about 3 000 ft. The upper 600 ft. penetrated bed-rock below the wash material of the creek, the bottom of the tunnel being about 110 ft. below the creek bed. The cost was about $50 000, and records for the past fifteen years show an average July output of 116 miners' in.

Fig. 1, Plate XXX, shows the mouth of the tunnel and the measuring weir. At the time the picture was taken there were about 150 miners' in. discharging from the tunnel. Later, the company acquired another tunnel, east of the colony, known as the "Cucamonga" tunnel, which has a discharge record of about 200 miners' in. While ample for all demands in years of average rainfall, this gravity supply was insufficient for years of drought. To meet the needs of dry years large tracts of water-bearing lands were purchased, both east and west of the colony, at Claremont and Cucamonga. Fifteen wells have been sunk, and pumping plants installed, with the result that the company is able, at all times, to supply the demands of the stockholders.

Pipe System.—The whole colony is piped throughout, the water company delivering water to domestic users through iron pipes; or, in the case of subsidiary companies, to some point sufficiently high

PLATE XXX.
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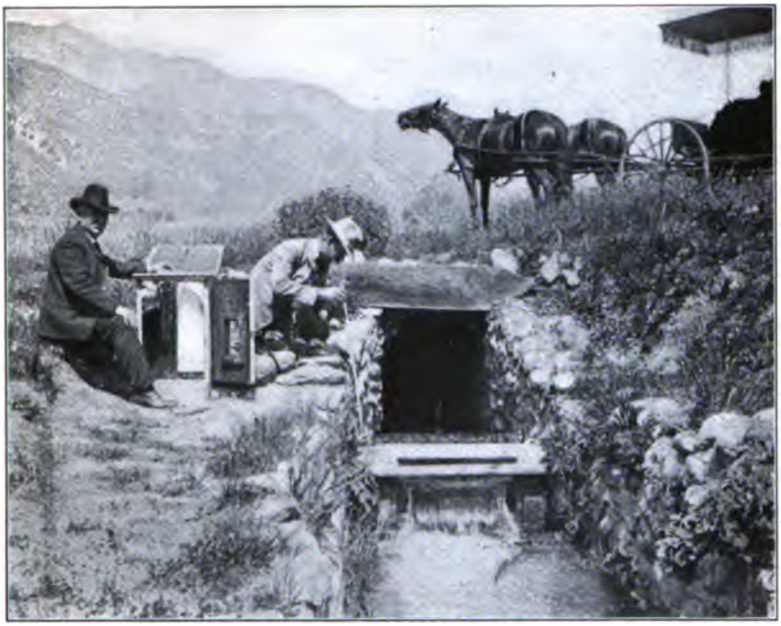

FIG. 1.—MOUTH OF SAN ANTONIO TUNNEL.

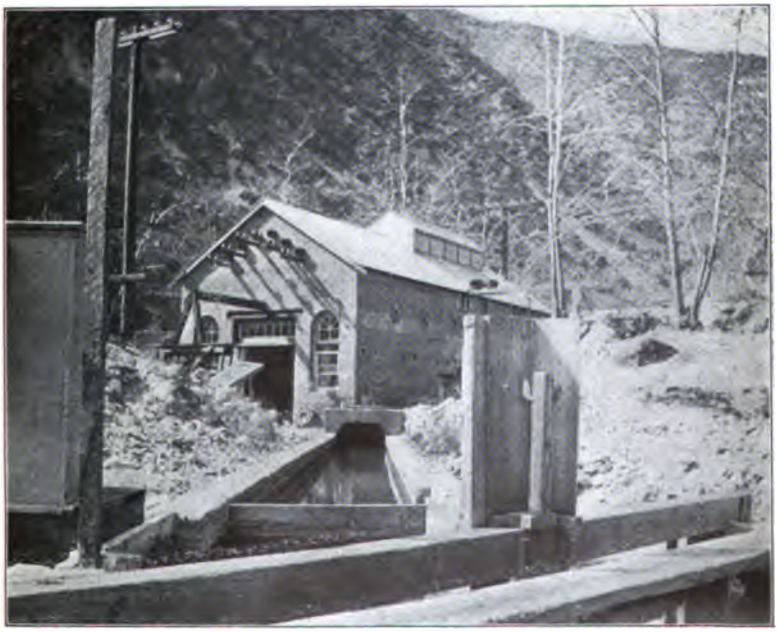

FIG. 2.—POWER PLANT NO. 1, TAIL-RACE AND INTAKE TO PLANT NO. 2.

to give domestic pressure; and to irrigators, at the highest corner of each 10-acre tract. The whole system consists principally of cement concrete pipe and vitrified clay pipe, ranging in diameter from 8 to 40 in. The system is complete and economic in that the loss of water in distribution is practically nothing. It is fitted with measuring weirs, division boxes and turn-out boxes built of concrete and so designed and arranged as to permit of rapid and complete control and distribution of the waters from the several sources from which the company draws its total supply.

Four large mains deliver to the colony the water from the four sources, *viz.*, San Antonio Cañon, Claremont, Cucamonga tunnel and Cucamonga gravel beds. Supplemental distributing and diagonal mains have been laid throughout the colony at different points, and in such a manner that those in control can readily shift the supply from different sources to different sections of the colony, thereby insuring an equal subdivision of the water to the various stockholders. Lateral pipe lines, mostly 8 in. in diameter, run north and south on lot lines, ½ mile apart, throughout the colony, delivering to irrigators a "30-in. head" every 30 days. The mileage and cost of the irrigation system, in detail, are shown in Table 1.

TABLE 1.—MILEAGE AND COST OF THE IRRIGATION SYSTEM IN DETAIL.

San Antonio tunnel	1.00 mile.	$50 000
Cañon ditch	0.60 "	6 000
" tunnel	0.10 "	1 000
16-in. cement conduit	0.62 "	1 980
3 x 4 ft. concrete conduit	0.61 "	6 480
30-in. cement pipe	0.57 "	4 500
24 " " "	0.80 "	4 725
22 " " "	1.00 "	4 752
20 " vitrified pipe	1.18 "	4 800
18 " " "	4.09 "	16 200
18 " cement "	0.40 "	1 470
16 " vitrified "	3.40 "	12 600
14 " " "	5.32 "	16 124
12 " " "	2.85 "	6 900
12 " cement "	0.91 "	2 208
10 " " "	9.52 "	18 105
10 " vitrified "	5.55 "	11 134
10 " sheet-steel "	1.00 "	2 112
8 " vitrified "	16.20 "	25 680
8 " cement "	30.07 "	44 464
7 " " "	0.62 "	660
Weir and division boxes, gates, etc.		25 000
Totals	86.36 miles.	$266 894

Hydro-Electric Plant.—Several years of expensive steam pumping influenced the San Antonio Water Company in a determination to develop its own water power in the cañon, not only to supply its own needs, but for sale and profit. This plant, completed in 1902, is now supplying all lighting demands of the colony, pumping from the company's wells, and contributing a considerable surplus to adjoining sections for various purposes. This is the third plant to utilize the San Antonio Cañon water for power, and it has proved a good investment.

Fig. 1, Plate XXXI, and Figs. 1 and 2, Plate XXXII, show this plant; Figs. 1 and 2, Plate XXXIII, show the sub-stations; Fig. 2, Plate XXXI, shows the laying of the pressure pipe; Fig. 2, Plate XXX, shows Power Plant No. 1, with its tail-race and the intake to Plant No. 3, or the San Antonio Water Company plant; and Figs. 1 and 2, Plate XXXIV, show Plant No. 2. Plants Nos. 1 and 2 are the property of the Pacific Light and Power Company, of Los Angeles, and are mentioned here solely because they are factors in developing the maximum utility of the water supply of this system.

Plant No. 3, as the property of this water company, became the important factor in the perfection of this irrigation system. It rounded out the completed design to such a degree that the management is able—at a nominal cost—to maintain a constant and ample supply of water for all consumers, notwithstanding the great fluctuations in the annual rainfall. It is located at *B*, on Plate XXIX, and diverts the water from the creek at *A*, into and through a 30-in. gravity conduit. The principal part of this conduit is cement concrete pipe. A portion of it is laid through tunnels, the remainder in a trench around the mountain side, with a part of the line, composed of steel inverted siphons, crossing side cañons. The wheels at the power-house have a working head of 700 ft., the water being delivered from the end of the gravity line, northwest of the power-house, through a steel pressure line, part of which is composed of riveted steel, the remainder or lower end being of 20-in. lap-welded tubing. The pressure lines were designed with a factor of safety of 5, and, after two years' service, are in perfect condition.

The equipment in the station consists of three direct-connected units, each composed of a 5-ft. Doble wheel and a 250 k. w. General Electric generator. The units are similar, and each is controlled

PLATE XXXI.
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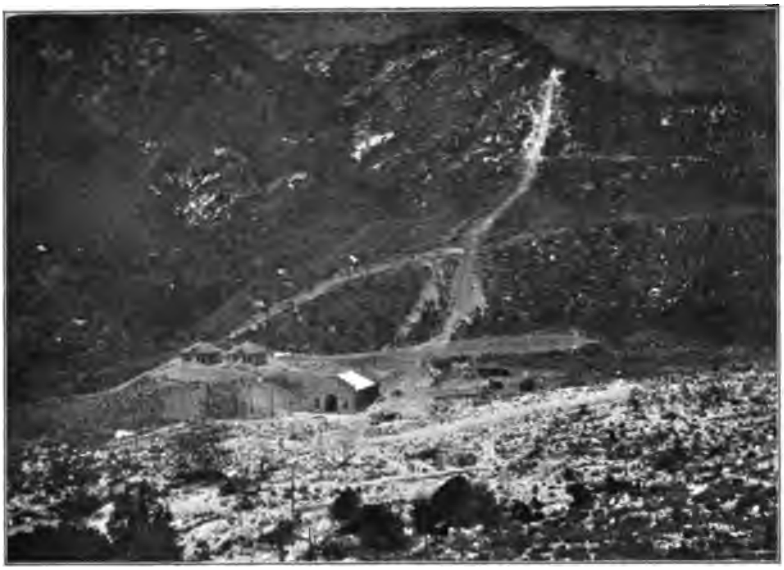

FIG. 1.—GENERAL VIEW OF LOCATION OF POWER-HOUSE.

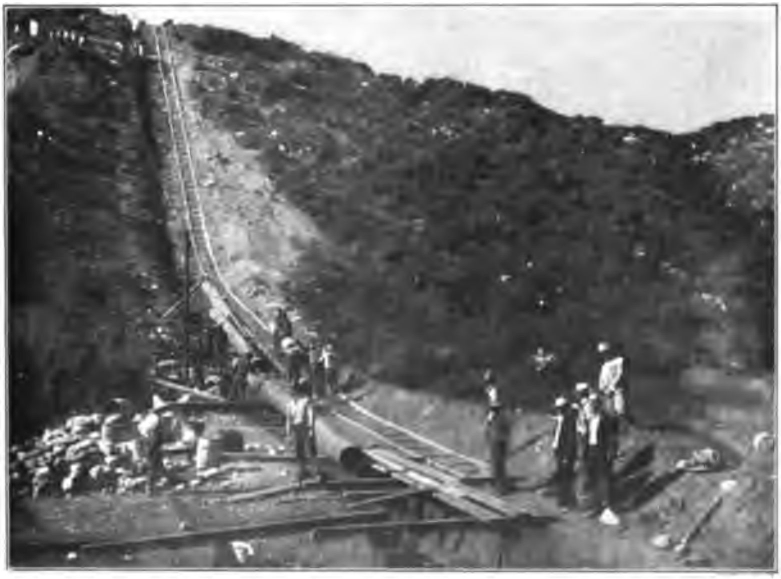

FIG. 2.—LAYING PRESSURE PIPE.

by a Lombard governor. Electricity is generated at 11 500 volts and is transmitted direct to the sub-stations at this voltage. The station building is of stone with a steel roof and is supplied with a traveling crane. The equipment is the latest and best put out by the General Electric Company and the Abner Doble Company, who, together, supplied the entire installation. The normal output of this plant is 750 k. w., which, at times, is increased by over-loading.

The writer made tests of these units, and found the three to have an average efficiency of 77.7% at the switchboard, the efficiency of the Doble wheel being 83.6 per cent.

Near the station the company built two stone cottages for employees, and in the rear there is a shop for repairs and experimental work.

The sub-stations are substantially built of wash boulders and neatly and thoroughly equipped with switch-boards, transformers and accessories. Pumping operations are directed from the upper station, one man being sufficient to operate as many as eight wells within a radius of a mile. The well equipment consists of an induction motor, belted to a centrifugal pump, and, when properly adjusted, it requires very little attention from the operator. The cost of the electric plant was as follows:

Power-house and two cottages	$ 5 647
Gravity conduit, 30-in.	63 000
Pressure pipe line	14 863
Three Doble 5-ft. wheels and accessories	8 218
Power-house wiring, etc.	1 872
Three alternating, 3-phase, revolving-field, 16-pole, 250-k. w. generators, with switch-boards, transformers and all accessories, complete in place	25 686
Lighting sub-station, building and equipment	10 814
Pumping " " " " "	6 275
Distributing system, motors, meters, lines, etc.	55 718
Total	$192 093

Conclusion.—The natural conditions at Ontario made it possible to develop this irrigation system with a high degree of economy and a maximum utility. The small surface stream of the mountains first develops electrical energy to pump additional water from the gravel beds below, to light and to heat the homes of the people, and to propel the street car lines of the colony; second, it irrigates the orchards lying on the foothills and above the gravel beds of the pumped water supply; and, third, that portion of the water not consumed by evaporation and plant life sinks into the gravel beds underlying these orchards—replenishing the storage there—to be pumped to the surface and used again for irrigating orchards at a lower level. The conduit system, being closed and adequately provided with division weirs, measuring boxes and gates, delivers the supply to consumers without loss.

The initial work on this system was under Messrs. Chaffee and Dunlap, engineers, who were interested with the promoters of the enterprise. In 1887 the writer took charge of the works, designing, remodeling and extending them from time to time, as the increasing needs of consumers dictated.

W. H. Sanders, M. Am. Soc. C. E., was engineer for Electric Plants Nos. 1 and 3, the writer acting in the same capacity for Electric Plant No. 2.

PLATE XXXII.
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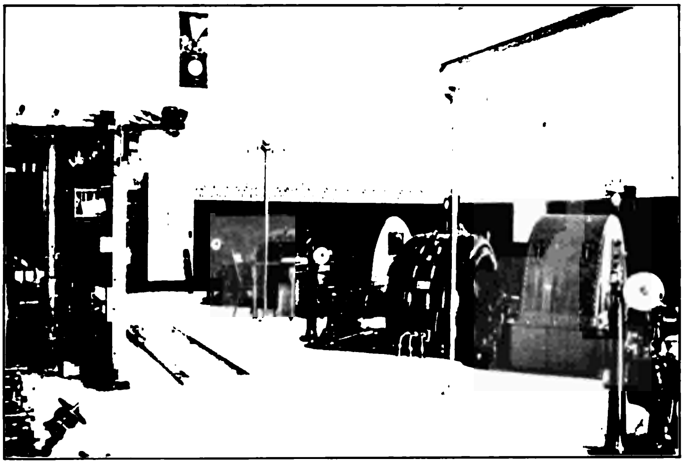

FIG. 1.—INTERIOR OF POWER-HOUSE, SHOWING TWO OF THE THREE GENERATOR SETS OF PLANT NO. 3.

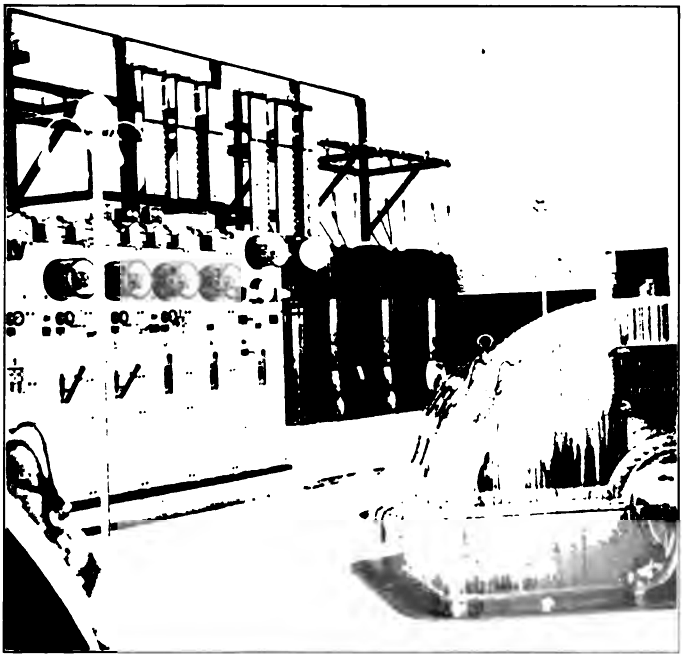

FIG. 2.—INTERIOR OF POWER-HOUSE, SHOWING SWITCH-BOARD AND TRANSFORMERS OF PLANT NO. 3.

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PAPERS AND DISCUSSIONS.

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A FEW POINTS IN THE DESIGN OF REINFORCED CONCRETE ARCHES.

BY B. R. LEFFLER, ASSOC. M. AM. SOC. C. E.

TO BE PRESENTED JUNE 7TH, 1905.

The object of this paper is to set forth some short processes in the graphical analysis of the elastic arch. The method given by William Cain, M. Am. Soc. C. E., in his book on Steel-Concrete Arches will be the basis. The reader is supposed to be familiar with this method.

The design of the arch section for a given thrust and moment, as determined by the line of resistance, will be commented upon. The effect of a direct thrust and moment acting simultaneously on a section is not clearly understood by some designers.

Let t be the vertical distance from the gravity axis to the line of resistance. Then, if the arch ring is properly divided into small lengths, the following are the fundamental conditions for an arch without hinges: $\Sigma\, t = 0$, $\Sigma\, t\, x = 0$, and $\Sigma\, t\, y = 0$. In which x and y are the co-ordinates of any point. Briefly, the preliminary work is this: The external loads having been determined, a load

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line is laid off, a trial pole assumed, and a trial equilibrium polygon is drawn. The true closing line of this polygon is then determined.

It is a common practice to find four lines of resistance corresponding to the arch fully loaded, three-quarters loaded, one-half loaded, and one-quarter loaded. Any method of lessening the labor of determining the closing line for the trial equilibrium polygon is desirable, since there must be a trial polygon for each loading. One object of this paper is to set forth a short method.

Let Fig. 1 represent an outline of an arch ring with a trial equilibrium polygon located. Let *m m′* be the true closing line. By Cain's method, a trial closing line, *n n′*, would be first assumed. Now no restrictions being placed upon the position of *n n′*, it will be assumed entirely out of the trial polygon. In this same figure, let *A B C* be any right triangle in which *A B* covers all the ordinates covered by the trial polygon. Treat all the ordinates included in the triangle as forces, finding their resultant in amount and position. Similarly, as per Cain's method, this resultant is a trial *T′*, and will be located to the right of the center of the arch. A like trial *T* is found at the same distance to the left of the center. By this method $T' = T$ always.

The following proposition will now be enunciated. *These trial T's, in position and amount, can be used for locating the true closing line for any trial equilibrium polygon that may be drawn.*

The demonstration of this proposition is so simple that it will not be given.

Let *R* be the resultant, in position and amount, of the ordinates included in the trial equilibrium polygon. Having *R* and the position of the trial *T*'s, which is the same as for the true *T*'s, we can find the true *T*'s as per Cain's method. The ordinates for the true closing line can then be computed.

$$V_2\,m = \frac{C\,B \times \text{true } T}{\text{Trial } T}, \text{ and } V_1\,m' = \frac{C\,B \times \text{true } T'}{\text{Trial } T}.$$

In the above expressions, $\frac{C\,B}{\text{Trial } T}$ is a constant. Let n = the number of divisions in the span. Trial $T = \frac{C\,B\,(n+1)}{2}$. Hence $\frac{C\,B}{\text{Trial } T} = \frac{2}{n+1}$. Substituting in the above expressions, $V_2\,m = \frac{2}{n+1}$ (true T), $v_1\,m' = \frac{2}{n+1}$ (true T').

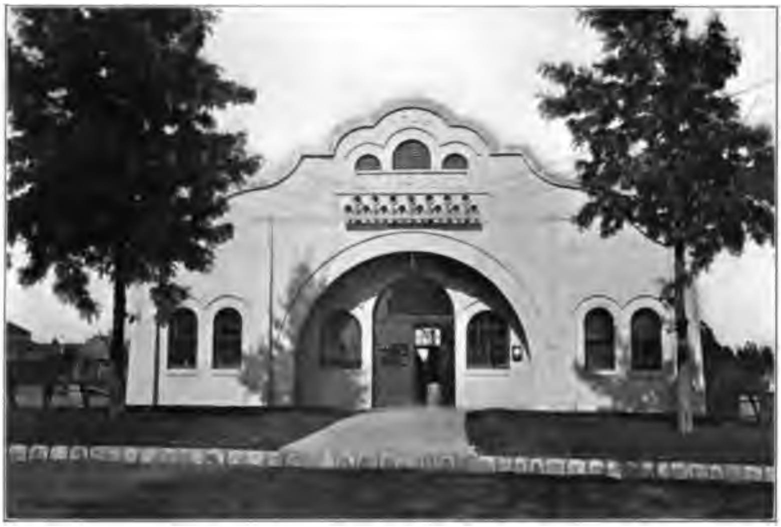

FIG. 1.—FRONT ELEVATION OF LIGHTING SUB-STATION.

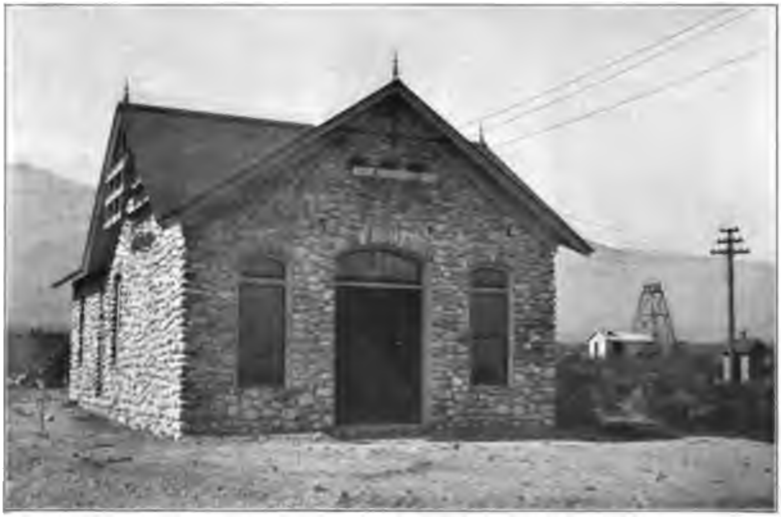

FIG. 2.—SUB-STATION FROM WHICH THE COMPANY'S WELLS ARE PUMPED.

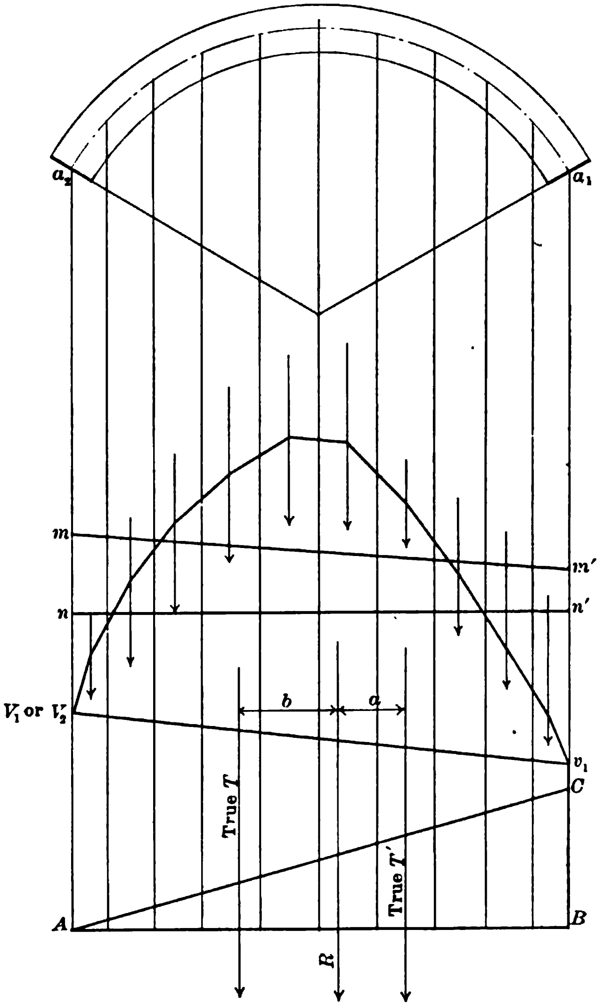

FIG. 1.

These expressions are still further simplified by dividing the arch span into equal parts.

Assume the arch span divided into equal parts. As to the requirements for this condition, the reader is referred to Cain's Solid and Braced Elastic Arches.* If these requirements are ignored, the error is probably small. A somewhat similar condition is met in computing the reactions of draw bridges. The writer refers to the assumption of a constant moment of inertia.

A method of calculating $V_1 m$ and $v_1 m'$, the ordinates of the true closing line, will now be deduced. As before, assume a right triangle, *A B C*, Fig. 2, but having its base divided into equal parts. Let α be the tangent of the angle at *A*. Let *n* equal the number of equal parts in the span. The remaining symbols are evident from the figure. As before, treat the ordinates as forces. Taking moments about *A*:

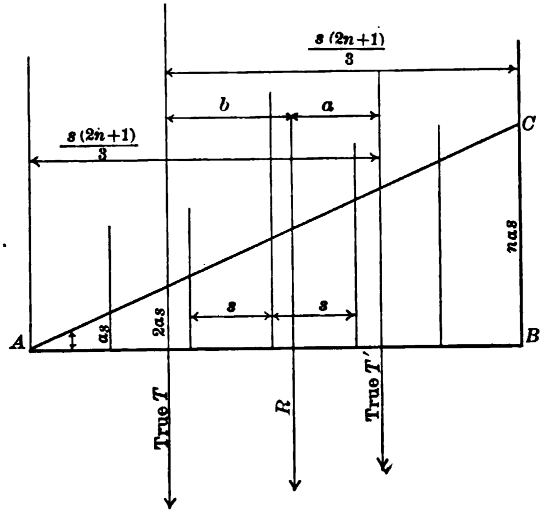

FIG. 2.

$$M = \alpha s^2 + 4\alpha s^2 + 9\alpha s^2 + \ldots\ldots n^2 \alpha s^2.$$

$$\text{Distance to trial } T' = \frac{\alpha s^2 (1 + 4 + 9 + \ldots\ldots n^2)}{n \alpha \frac{s}{2} (n+1)} =$$

$$\frac{2s}{n(n+1)} \left[\frac{n(n+1)(2n+1)}{6}\right] = s\,\frac{(2n+1)}{3}.$$

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* Page 76.

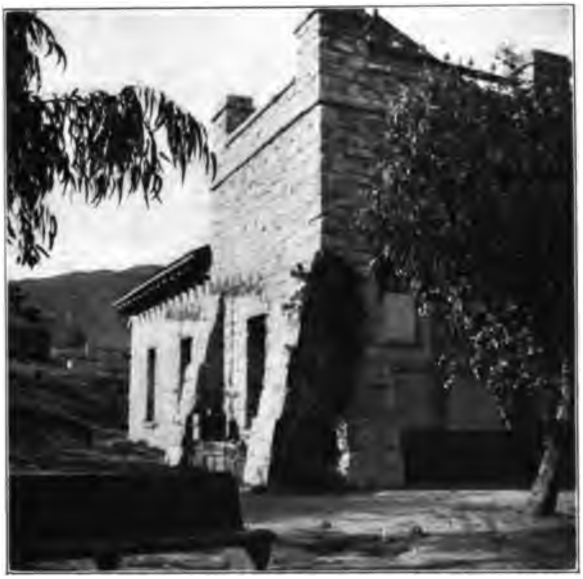

FIG. 1.—POWER-HOUSE NO. 2.

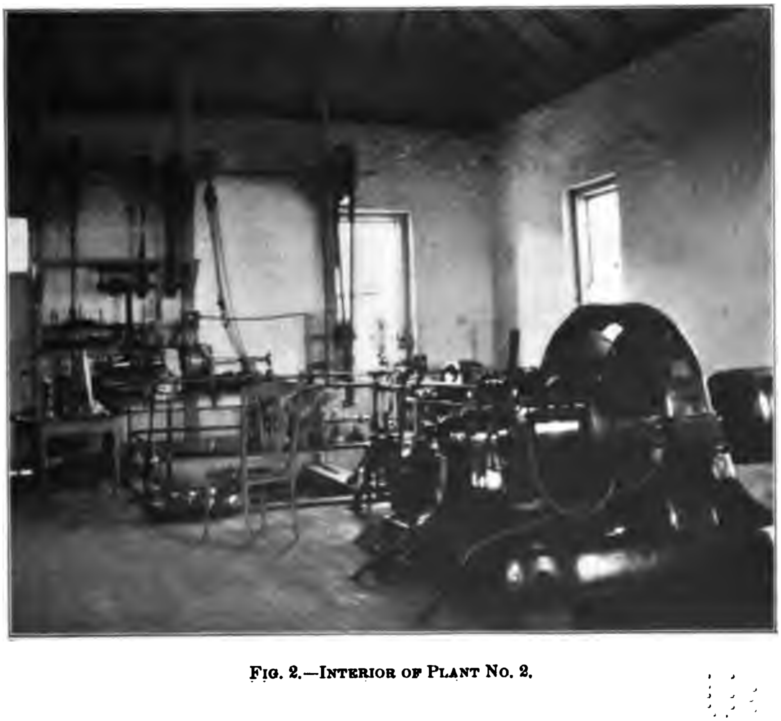

FIG. 2.—INTERIOR OF PLANT NO. 2.

Trial $T' = \alpha\, s\, n \frac{(n+1)}{2}$, evidently.

True T' and T will now be calculated. Let a be the distance from T' to R, and b of T to R. The distance between T' and T is $\frac{2s}{3}(2n+1) - ns$, which, of course, equals $a + b$. Take origin of moments on T'. Then $R\,a = \left[\frac{2s(2n+1)}{3} - ns\right]$ true T,

$$\text{True } T = \frac{3Ra}{2s(2n+1) - 3ns},$$

$$\text{and True } T' = \frac{3Rb}{2s(2n+1) - 3ns}.$$

Using these values for the true T's we have, as before,

$$V_1 m = \frac{2}{n+1}\,\frac{3Ra}{2s(2n+1) - 3ns} = \frac{6Ra}{s(n+2)(n+1)}.$$

Similarly, for $v_1 m'$.

It is impossible to present the full theory of the elastic arch in a single paper. For this reason the reader is supposed to be familiar with Cain's method.

The figures shown are not actual examples of an arch, but are simply intended to illustrate the location of the true closing line of the equilibrium polygon. Hence, no force diagram, or line of resistance is shown.

After the true closing line and true pole are located, the line of resistance can be drawn in its correct position in the arch ring. It can then be seen where the line passes out of the middle third.

Wherever the line of resistance passes out of the middle third of the plain concrete section steel is required.

The steel is usually placed symmetrically about the gravity axis of the concrete. The center of gravity of the compound section is thus the same as for the plain concrete section. The moment is measured by the product of the direct thrust into the distance of the line of resistance from the center of gravity. *This moment cannot produce tension in the concrete unless the line of resistance is out of the middle third of the plain concrete section.*

There is only one set of formulas, as far as the writer knows, which seems to show correctly the effect of the direct thrust and moment on an arch section of reinforced concrete. These formulas are given by Cain, and were first published by Thacher. The formulas are:

$$s_1 = \frac{T}{A_1 + n\,A_2} \pm \frac{M\,v_1}{I_1 + n\,I_2},$$

$$\text{and } s_2 = \left[\frac{T}{A_1 + n\,A_2} \pm \frac{M\,v_2}{I_1 + n\,I_2}\right] n.$$

If these formulas are applied to any section in which the line of resistance passes within the middle third, it will be found that the steel takes no tension.

This middle third theory cannot be too strongly emphasized, for the impression seems somewhat prevalent that steel is required wherever there is moment. Whereas it is only required where tension in the concrete is produced.

The Railway Age of January to April, 1904, contained a series of articles, afterward issued in pamphlet form, in which the theory of putting in steel to take moment is exemplified.* A reinforced concrete beam formula similar to Johnson's was used. The writer fails to see how a formula like Johnson's or Hatt's can be rationally applied to a case of combined thrust and moment.

Theory shows that the voussoir arch with good joints behaves as a curved elastic beam as long as the line of resistance does not pass out of the middle third. Railroad engineers build reinforced concrete arches with considerable depth of ring, almost the same as for a voussoir arch. This being the case, the line of resistance does not deviate very much from the middle third, except in the case of the dead load being a small part of the total load. Hence, for a deep concrete ring very little steel will be required for flexure. But if steel is put in for moment, erroneously, much steel may be used. The use of steel to prevent shrinkage cracks is not now under consideration.

It is probable that railroad engineers are too conservative in the use of an arch ring of shallow depth. It is only by the use of such a ring that the steel can be made to resist tension.

The main objects of this paper are to introduce some improvements in the graphical analysis of the arch, and to emphasize the middle-third theory.

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* See pages 38 and 39 of pamphlet.

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PAPERS AND DISCUSSIONS.

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THEORY OF THE SPHERICAL OR CONICAL DOME OF REINFORCED CONCRETE OR METAL.

By William Cain, M. Am. Soc. C. E.

To be Presented June 7th, 1905.

1.—The domes that will be considered in this paper are supposed to be solids of revolution, as to figure; and to be constructed of material such as metal or reinforced concrete, capable of sustaining either tensile or compressive stresses.

The masonry dome can only resist compressive stresses, and, as it has been considered somewhat in detail by the writer,* it will not receive special mention in what follows. It may be remarked, however, that the theory concerning the upper part of any dome, where compressive stresses only are experienced, is common to all domes, whether of metal, reinforced concrete or masonry, so that much that follows pertains to both classes of domes. Both analytical and graphical methods of solution will be given, though the former only applies to the spherical or conical dome of constant thickness, while, in the latter, no such restriction is imposed. Another advantage in the graphical method lies in its simplicity and clearness in interpreting results exactly. In this way it is an aid to the analytical method.

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* "Theory of Steel-Concrete Arches and Vaulted Structures." D. Van Nostrand Co., publisher.

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In Fig. 1 is shown a dome in which the soffit is supposed to be generated by revolving some curve about the vertical axis. The extrados may be similarly generated, using either a curve or any other figure for the generating line. If we pass, through the axis, two meridian planes making an angle, ψ, with each other, we cut from the dome a portion of a wedge, $F\ C$. Next conceive conical joints perpendicular to the soffit, certain distances apart, and call the part of the dome, as $D\ E$, lying between any two successive conical joints a crown. The four curved edges of a crown evidently lie in horizontal planes. It is convenient to call the portion, V, of the crown, $D\ E$, lying between the two meridian planes, a voussoir, though, of course, there are no true voussoirs in the metal or concrete dome.

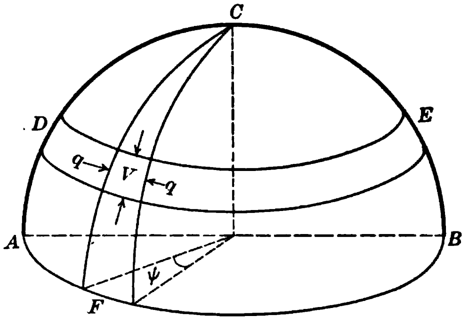

FIG. 1.

A voussoir is thus the portion of a dome included between two contiguous conical joints and between two meridian planes which make an angle, ψ, with each other

The upper part of the dome, under the influence of gravity, tends to fall, and thus induces stresses at all the supposed joints; the magnitude of these stresses it is the object to find. The voussoir, V, as part of the crown, $D\ E$, is subjected to horizontal pressures (or tensions), q, on its vertical faces, and it likewise sustains a meridional thrust acting downward on its upper conical face and a meridional thrust acting upward on its lower conical face. The forces acting on the voussoir, which must be in equilibrium, are thus, its own weight, the two forces, q, and the two meridional thrusts mentioned. The latter are called meridional thrusts because they act in a meridian plane dividing the voussoir in half.

2.—In the investigation that follows, the resultant, Q, of the two forces, q, q, is first found, and from it and the given angle, ψ, q is computed from the formula below. Since q, q are both horizontal, it follows that Q is horizontal.

To find the relation between Q and q, consider the plan of the voussoir, $A\ B$, Fig. 2, where Q, of course, bisects the angle, ψ, and q, q act perpendicularly to the vertical faces, and hence to the radii drawn at A and B. The sum of the components of q, q, parallel to Q, equals Q.

$$\text{Therefore, } Q = 2\, q \sin. \frac{1}{2}\, \psi.$$

As eventually we will suppose ψ to be expressed in circular measure and equal to $\frac{1}{n}$ of the circumference of a unit circle $\left(i.\ e., \psi = \frac{2\,\pi}{n}\right)$, and will suppose n very large; then ψ will be very small, and can be made to differ from sin. ψ by as small a quantity as we choose, by sufficiently increasing n. Hence, on replacing sin. $\frac{1}{2}\,\psi$ by $\frac{1}{2}\,\psi$,

$$q = \frac{Q}{\psi} = \frac{Q\,n}{2\,\pi} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Here, Q is the resultant of the forces, q, q. If Q acts to the left, as in the figure, q, q, cause compression in the "crown," $D\ E$, Fig. 1; whereas, if Q acts to the right, the directions of q, q, are reversed, and tension is exerted in the crown.

If a circular steel band or hoop is subjected to a uniform normal pressure, the relation between the force, F, representing the resultant of the pressures on a portion, $A\ B$, of the hoop, subtending the very small angle, ψ, and the resulting tension, T, in the hoop, Fig. 3, is similarly found to be:

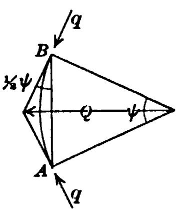

FIG. 2.

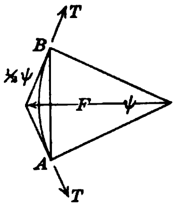

FIG. 3.

$$T = \frac{F}{\psi} = \frac{F\,n}{2\,\pi} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

on noting that T, T and F are in equilibrium. F is here opposed to the resultant of the forces, T, T.

3.—Complete Spherical Dome of Constant Thickness, t feet. Graphical Method.—Let r be the radius, in feet, of the center line of the portion of the dome, $F\,C$, Fig. 1, included between the two meridional planes.

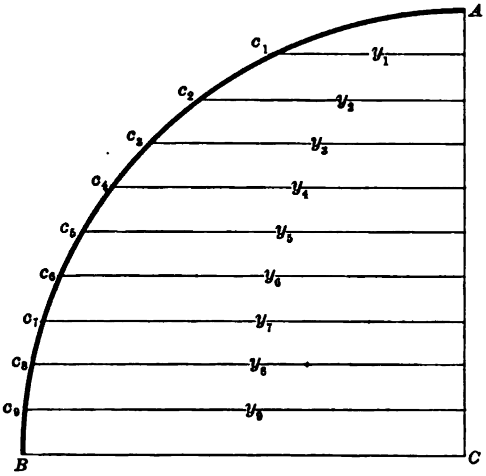

FIG. 4(*a*).

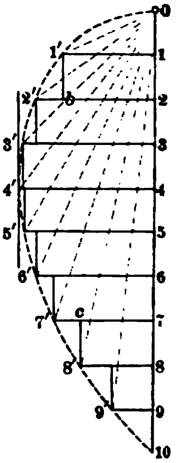

FIG. 4(*b*).

In Fig. 4(*a*), this center line is represented by the quadrant, $A\,B$, described with C as a center and r as radius $= B\,C = A\,C$. The axis, $C\,A$, is vertical. Divide $A\,C$ into any number of equal parts (10 in the figure), each of length a, and draw horizontals through the points of division, meeting the curve at c_1. c_2, ... The area of the zone generated by revolving any of the arcs, Ac_1. c_1c_2, c_2c_3, ..., about $A\;C$, each having the altitude, a, is, by geometry, $2\;\pi\;r\;a$, and the weight of the corresponding shell (or "crown" of Fig. 1) is, if the material weighs w pounds per cubic foot, $2\;\pi\;r\;a\;w\;t$. The weight of the corresponding voussoir, V (Fig. 1), is $\frac{1}{n}$ of this.

Therefore, weight of voussoir $= \frac{1}{n}\;2\;\pi\;r\;a\;w\;t = \psi\;r\;a\;w\;t$.

This represents the weight of the successive voussoirs, Ac_1, c_1c_2, c_2c_3,...., of Fig. 4(*a*), as the succcessive arcs will now be supposed to refer only to the corresponding voussoirs.

Compute $r\ a\ w\ t$, and, to any scale, lay off on the vertical, 0-10, Fig. 4(*b*), $0\,1 = 1\,2 = 2\,3$, etc., each equal to $r\ a\ w\ t$. The weight of any voussoir is thus represented by ψ times the lengths, 0 1, 1 2, etc., so that the measure of each line in the force diagrams must be multiplied by ψ to give the true result. Of course, the scales used in Figs. 4(*a*) and 4(*b*) should be as large as convenient. 0-10 is not generally of the length, *A C*. It was drawn so in the figure the better to suit the conveniences of the page. The meridional thrusts at c_1, c_2,...., are assumed, as in the analytical theory, to be tangent to the center line ($A\,c_1c_2...B$). Hence, in Figs. 4(*a*) and 4(*b*), draw $0\,1'$, $0\,2'$,...., perpendicular to the radii at c_1, c_2,...., to give the direction of the meridional thrusts at c_1, c_2,..... There is no thrust at the summit, *A*, since the surface of the conical joint there reduces to a line and there can be no pressure on a line. The forces acting on the first voussoir, $A\ c_1$, are its weight (represented by 0 1 in Fig. 4(*b*)), the upward meridional thrust at c_1, and the two forces, *q*, *q*, the resultant of which replaces them in the triangle of forces, $0\ 1\ 1'$, formed by drawing a horizontal through 1 to meet $0\ 1'$ at $1'$. On following around the triangle in the order $0\ 1\ 1'\ 0$, we see that Q_1, represented by $1\ 1'$, acts to the left; hence the forces, *q*, *q*, cause compression. Q_1, of course, acts at the intersection of the tangent at c_1 with the vertical through the center of gravity of the voussoir, $A\ c_1$. It will not be necessary, though, to find the position of any of the *Q's*.

Draw, in Fig. 4(*b*), horizontals through 2, 3,...., to meet $0\,2'$, $0\,3'$, ..., at $2'$, $3'$, ..., respectively. Also, verticals are drawn at $1'$, $2'$, $3'$, ..., as shown. The force diagram for the second voussoir, c_1c_2, is $0\,1'\ b\ 2'\,0$; $0\,1'$ representing the downward meridional thrust at c_1; $1'\ b$ the weight of the voussoir; and $b\ 2'$, Q_2 and $2'\ 0$ the upward meridional thrust exerted by the third voussoir upon the second at c_2. Since Q_2 acts to the left, the crown in which the second voussoir is placed is everywhere in compression. The construction is continued as before for all the voussoirs, as shown in Fig. 4(*b*). About c_4 the forces, *Q*, change sign, being directed to the left above c_4 and below it, to the right.

Thus the polygon of forces for the voussoir, c_7c_8, is 0 7′ c 8′ 0; 0 7′ representing the downward meridional thrust at c_7, 7′ c the resultant of the corresponding q's $= Q_8$; c 8′ the weight of the voussoir, c_7c_8, and 8′ 0 the upward meridional thrust at c_8, exerted by the ninth voussoir upon the eighth. Since 7′ c acts to the right, there is tension exerted on its vertical faces throughout the crown, of which voussoir, c_7c_8, is a part. Q is greatest near the summit and near the base, and least about c_4.

In a concrete dome, the tension exerted around the successive crowns can be resisted mainly by an enclosed steel hoop, preferably shaped so as to give a mechanical bond between the steel and the concrete.

4.—Meridional Thrust per Unit of Length of Horizontal Circumference.—Since the weights of successive voussoirs were assumed to be ψ 0 1 $= \psi$ 0 2, etc., the numerical measures of the lines in Fig. 4(b), representing meridional thrusts, values of Q, etc., must each be multiplied by ψ to get the true thrust, etc., in pounds. Thus the meridional thrust at c_2 is ψ 0 2′. This thrust acts on a horizontal width of voussoir $\frac{2\,\pi\,y_2}{n} = \psi y_2$, if we call y_2 the radius of the horizontal circle at c_2. Hence, the meridional thrust per unit of length of horizontal circumference is ψ 0 2′ divided by $\psi\ y_2$, or $\frac{0\ 2'}{y_2}$.

In this way we find the meridional thrusts per unit of length of horizontal circumference

$$\text{at}\ldots\ldots\ldots\ldots c_1,\quad c_2,\quad c_3,\ldots\ldots\ldots\ldots,$$
$$\text{to be},\ldots\ldots\ldots\ldots \frac{0\ 1'}{y_1},\ \frac{0\ 2'}{y_2},\ \frac{0\ 3'}{y_3},\ldots\ldots\ldots\ldots;$$

where 0 1′, 0 2′, 0 3′, mean the numerical measures of the lines, 0 1′, 0 2′, 0 3′, to the scale of force used in Fig. 4(b). The thrusts are thus given in pounds. They each act on an area, $1 \times t = t$ square feet, nearly, so that, on dividing any thrust by t we obtain the unit stress, in pounds per square foot, on the conical joint at that depth. The thrusts increase in going from A to B, Fig. 4(a).

5.—Average Horizontal Side Thrust (or Pull) on the Vertical Face of a Voussoir, per Unit of Length of Meridian.—Let us consider the second voussoir. For it, $Q_2 = \psi\, b\, 2'$; whence, by Equation 1, the thrust around the "crown," including voussoir, $c_1 c_2$, is,

$$q_2 = \frac{Q_2}{\psi} = b\, 2'.$$

Let the length, in feet, of the arc, $c_1 c_2$, be designated by s_2; then the average side thrust on the voussoir, per unit of length of meridian, is $\frac{b\, 2'}{s_2}$, and the average stress exerted, per unit of area, is $\frac{b\, 2'}{s_2\, t}$.

As before, $b\ 2'$ means the numerical measure of the line, $b\ 2'$, Fig. 4(b), to the scale of force.

Similarly, if the length of the arc, $c_7 c_8$, in feet $= s_8$, the pull around the crown in which the voussoir, $c_7 c_8$, lies, per unit of length of meridian, is $\frac{7'\, 2}{s_8}$; or generally, if we designate the horizontal projection lengths (measured to scale of force) of $0\,1'$, $1'\,2'$, $2'\,3', \ldots.,$ by $b_1, b_2, b_3, \ldots.,$ and the corresponding lengths of arc $A\ c_1,\ c_1 c_2,\ c_2 c_3, \ldots.,$ in feet, by $s_1, s_2, s_3, \ldots.,$ then the average side thrust (or pull) on the vertical faces of voussoirs,

$$A c_1,\ c_1 c_2,\ c_2 c_3,\ \ldots.,$$

per unit of meridian length will be, $\frac{b_1}{s_1}, \frac{b_2}{s_2}, \frac{b_3}{s_3} \ldots.,$ respectively.

These ratios are greatest for the highest and lowest voussoirs.

6.—Hoop Tension.—Let us conceive that the dome only extends from A to the horizontal circle through c_4, where it is supported by a cylindrical wall. The part of this wall, or abutment, contained between the two meridional planes making an angle, ψ, with each other, must be capable of resisting the downward thrust, $\psi\ 0\,4'$ pounds. If it is too narrow to withstand the horizontal component of this thrust, $\psi\ 4\,4'$ pounds, a steel hoop may be made to encircle the dome at the level of c_4, and, by Equation 2, the tension, T, in it will be,

$$T = \frac{\psi\, 4\, 4'}{\psi} = 4\, 4' \text{ pounds},$$

where $4\,4'$ means the numerical measure of the length, $4\,4'$, Fig. 4(b), measured to the scale of force.*

---

* This gives results agreeing with Rankine's formula for hoop tension (where it is a maximum), $0.3\ r^2\, w\ t$, on substituting $r = w = t = 1$. Here, $a - \frac{1}{10}\, r - \frac{1}{10} - 0\,1 - 0\,2$, etc., in Fig. 4($b$), since $0\,1 - r\, a\, w\, t$, and $4\,4' -$ hoop tension, measures 0.3. The point of maximum hoop tension is really at 0.618 r above C, Fig. 4(a); but the tension there differs from $4\,4'$ inappreciably, as is evident from Fig. 4(b).

Similarly, we can suppose the abutment successively at c_1, c_2, c_3, ..., and the consequent hoop tensions will be in pounds, the lengths of $1\,1'$, $2\,2'$, $3\,3'$, ..., in turn, all measured to the scale of force.

A sharp distinction must be drawn between the total horizontal thrust at a joint, other than c_1. and the value of Q pertaining to the voussoir in the crown just above it. Thus, for the second voussoir. $Q = \psi\ b\ 2'$, but the total horizontal thrusts exerted at c_1 and c_2 are $\psi\ 1\,1'$ and $\psi\ 2\,2'$, respectively. We have $2\,2' = 1\,1' + b\,2'$, also $7\,7' - c\ 7' = 8\,8'$, etc. Overlooking this point has sometimes caused some confusion.

The stresses in a masonry dome extending from A to the horizontal circle through c_4 (about) are ascertained exactly as just described. If the dome extends below the level of c_4, the supposed wedges below c_4 contained between meridian planes, act as simple arches, and the thickness must be materially increased as we approach B, Fig. 4(a), which is expensive. The alternative is the use of a metal band or bands, unless the stones can be cut and joined so as to resist tension.

7.—Open Spherical Dome.—Suppose the portion of the dome, Fig 4(a), from A to the level of c, to be removed. We will then have an open dome, and, of course, no pressure at c_1. The weight of the voussoir, Ac_1, is now zero; therefore 0 moves to 1 in Fig. 4(b) and the radiating meridional thrusts are drawn from $0 = 1$.

The subsequent constructions and conclusions are exactly as above, save that the point of maximum hoop tension is lowered.

8.—Open Spherical Dome with a Lantern.—Let Fig. 5(a) represent a half meridian section of a spherical dome, the center line of the shell being c_0-c_{37}, the portion above the level of c_0 being removed, and a lantern, of total weight, W, resting on the crown of the shell, the center line of which is c_0-c_4. Divide the vertical projection of the arc, c_0c_4, into (say) four equal parts, each of altitude a' and draw the horizontal radii, y_0, y_1, y_2, y_3, y_4, from the vertical axis, through the points of division to c_0, c_1, c_2, c_3, c_4.

Let p = weight, in pounds per square foot, of the horizontal section of the lantern.

$$\text{Therefore, } p = \frac{W}{\pi\,(y_4^2 - y_0^2)}$$

As before, consider the portion of the dome and load between two meridian planes making an angle, $\psi = \frac{2\pi}{n}$, with each other. The weight of the lantern resting on the voussoir $c_0 c_1$ is thus,

$$\frac{1}{n} p \pi (y_1^2 - y_0^2) = \frac{2\pi p}{n\ 2} (y_1^2 - y_0^2) = \psi \frac{p}{2} (y_1^2 - y_0^2).$$

Similarly, the lantern loads resting on the voussoirs, $c_1 c_2$, $c_2 c_3$, $c_3 c_4$, are, respectively,

$$\psi \frac{p}{2} (y_2^2 - y_1^2),\ \psi \frac{p}{2} (y_3^2 - y_2^2),\ \psi \frac{p}{2} (y_4^2 - y_3^2).$$

Add to each of these the weight of the voussoir on which it rests, $\psi\ r\ a'\ w\ t$ (Art. 4) and lay off to scale the successive sums divided by ψ from 0 on the vertical load line, Fig. 5(b), downward.

Thus the weight of the voussoir, $c_0 c_1$, and the lantern load $= \psi\ 0\,1$; the weight of the voussoir, $c_1 c_2$, with load $= \psi\ 1\,2$; of voussoir, $c_2 c_3$, and load, $\psi\ 2\,3$, and for voussoir $c_3 c_4$, $\psi\ 3\,4$.

Next, divide the vertical projection of the remaining arc, $c_4 c_{37}$ (Fig. 5(a)), into a number of equal parts, each of length a. Then, as in Art. 4, the weights of the corresponding voussoirs, $c_4 c_5$, $c_5 c_6$, etc., are each $\psi\ r\ a\ w\ t$. Hence, in Fig. 5(b), lay off $4\,5 = 5\,6$, etc., each equal to $r\ a\ w\ t$, completing the load line 0-37.

As before, from 0, Fig. 5(b), draw $0\,1'$, $0\,2'$, $0\,3'$, ..., perpendicular to the radii of the sphere at c_1, c_2, c_3, ..., giving the directions of the tangents to the arc, $c_0 c_{37}$, at c_1, c_2, c_3, ..., respectively. The horizontals through 1, 2, 3, ..., cut these rays at $1'$, $2'$, $3'$, ..., respectively. The force diagram is then completed by marking off the horizontal projections of $1'\,2'$, $2'\,3'$, etc.

The meridional, crown and hoop stresses are found now exactly as detailed in Arts. 4, 5 and 6. Thus the meridional thrusts per unit of length of horizontal circumference at c_0, c_1, c_2, ..., are, respectively,

$$0, \frac{0\,1'}{y_1}, \frac{0\,2'}{y_2}, \ldots.,$$

The tension in a hoop encircling the dome at the level of (say) c_4 is $4\,4'$ pounds; at c_9, $9\,9'$ pounds, etc.

Finally, if we designate the horizontal projections of $0\,1'$, $1'\,2'$, $2'\,3'$, $3'\,4'$, ..., (measured to scale of force) by b_1, b_2, b_3, b_4, ..., and the lengths of arcs, $c_0 c_1$. c_1, c_2, $c_2 c_3$, $c_3 c_4$, ..., (to scale of distance) in feet, by $s_1, s_2, s_3, s_4, \ldots$; then the average side stresses (compression or tension) on the vertical faces of voussoirs,

$$c_0c_1,\ c_1c_2,\ c_2c_3,\ c_3c_4,\ \ldots,$$

per unit of meridian length (the "crown stresses"), are,

$$\frac{b_1}{s_1},\ \frac{b_2}{s_2},\ \frac{b_3}{s_3},\ \frac{b_4}{s_4},\ \ .\ \ .\ \ .\ \ ,\ \text{pounds, respectively.}$$

The greatest crown stress is that on the voussoir, c_0c_1, and is

$$\frac{b'}{s_1} = \frac{1\,1'\ \text{(to scale of force)}}{\text{length of } c_0\,c_1,\ \text{in feet}}\ \text{pounds compression.}$$

This is evidently greater than the average crown stress on the voussoir, c_0c_4, which is $4\,4' \div$ length of the arc, c_0c_4.

In practice, the portion of the arc, c_0c_4, on which the lantern rests is of small length. Thus, in the dome of St. Peter's, at Rome, the thickness of the lantern at the base is only 2.1 ft. In Fig. 5(*a*), the lantern was given an abnormal thickness to make a plainer diagram and illustrate an important point hitherto unnoticed, *viz.*, that in a dome with a lantern, the slope of the curve, $0\,1'\,2'\,3'\,4'\,5'\ldots$, is discontinuous at 4′. The corresponding curve for a closed dome with no lantern is continuous as to slope. The rate of increase of the crown stress is thus discontinuous at the outside edge of the lantern. With a light lantern, even, although the crown stresses may be both compressive on either side of the outer edge of lantern, yet they make a sudden jump in passing this edge. With the very heavy lantern of Fig. 5(*a*), the crown stress in the voussoir, c_3c_4, is compressive, but for the voussoir, c_4c_5, and all below it, the crown stress is tensile. The sudden change in the slope of the curve occurs at 4′, and the curve below that has a point of inflection.

We are now prepared to find, in the analytical solution that follows, different formulas for the crown stresses on either side of c_4, however near to c_4 the points on either side of c_4 are taken.

This abnormality results from omitting the elastic yielding of the dome under stress. This yielding, due to crown stress, is greatest on the voussoir, c_0c_1, which brings the one below it more in action, as more of the weight of the lantern will then be transferred to it, and so on, down; besides, the direction of the meridional thrust just below c_4 is doubtless nearer the horizontal than drawn, throwing 5′ to the left. If the resultant meridional or crown stress passes

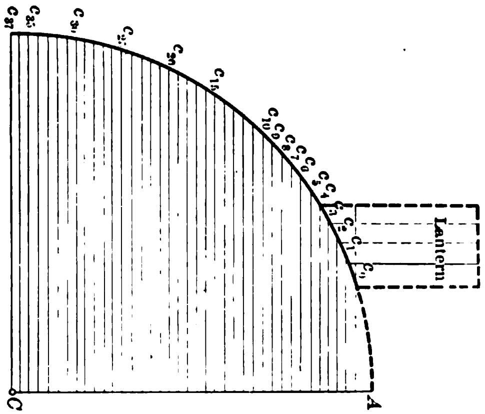
Lantern
C
A
C_0
C_1
C_2
C_3
C_4
C_5
C_6
C_7
C_8
C_9
C_{10}
C_{15}
C_{20}
C_{25}
C_{30}
C_{35}
C_{37}

FIG. 5(a).

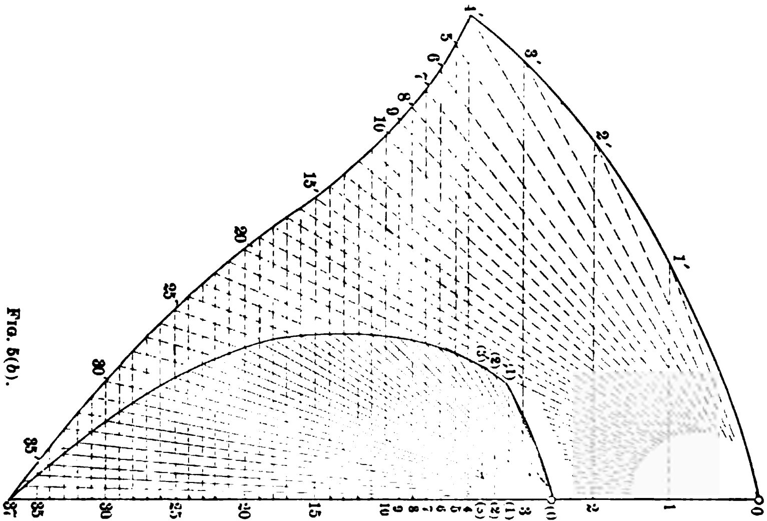
(0)
(1)
(2)
(3)

FIG. 5(b).

through the middle-third limit, the maximum unit stress on the joint is double the average. The elastic yielding of the dome will undoubtedly cause a non-uniform distribution of the stress over most of the (conceived) joints, and, to be on the safe side, it is wise to take the maximum unit stress as double the average, unless the dome is thicker than usual, when it may be assumed as less.

The lantern, for the given weight, p, per horizontal square foot, may be assumed to bear only upon c_0c_3, c_0c_2 and c_0c_1, in turn; but each curve, corresponding to $0\,1'\,2'\,3' \ldots .$, will have the same characteristics. As p diminishes, when c_0c_1 alone supports a lantern load, the curve gradually approaches the usual form for a closed dome with no lantern. Thus, on the load line, lay off $4(3) = (3)(2) = (2)(1)$ to represent the weight of the voussoirs, c_4c_3, c_3c_2, c_2c_1, divided by ψ and $(1)(0) = \frac{1}{2}\,0\,1$, for the weight of the voussoir, c_0c_1, with its lantern load, also divided by ψ. Taking (0) as a pole, the curve corresponding to $0\,1'\,2'\,3' \ldots .$, is drawn and it will be noticed that the crown stresses are not only compressive on either side of c_1 (the outer edge of the lantern), but continue so for some distance down. There is, apparently, still discontinuity of the slope at (1′).

9.—Analytical Theory of Spherical Domes.—Let Fig. 6 represent half of a vertical section through the axis, $O\ C$, of the dome. To take the most general case, let the dome be open above, with a circular opening, of radius $E\ O = y_0$, having a lantern resting on the arc, $D\ E$, of total weight $= W$ pounds. The small constant thickness of the dome is t feet and its weight per cubic foot is w pounds.

Take the origin at O, x vertical, y horizontal, and call the coordinates of P, $x = O\ N$, $y = N\ P$. The mean radius of the dome, $C\ P = C\ A = r$; the angle, α (in circular measure) $=$ the angle, $A\ C\ P$, and $C\ N = h$. Let $s =$ the length of the arc, $A\ P$; whence $s = r\,\alpha$, and, differentiating, $\frac{d\,\alpha}{d\,s} = \frac{1}{r}$. The differential triangle is drawn at P, whence

$$\frac{d\,x}{d\,s} = \sin.\alpha = \frac{y}{r};\quad \frac{d\,y}{d\,s} = \cos.\alpha = \frac{h}{r}.$$

The whole weight of the lantern and the part of the dome with altitude x, as before, is $(2\ \pi\,r\,w\,t\,x + W)$. As in previous articles, the part considered will be $\frac{1}{n}$ of this. contained between two meridian planes making an angle , $\psi = \frac{2\pi}{n}$ with each other. Thus

$$\frac{1}{n}(2\pi r w t x + W) = \psi r w t x + \frac{W}{n}$$

is the vertical load sustained at P, when P is below D, and since the meridional thrust there is supposed to act in the direction of the tangent at P, its value is,

$$\left(\psi r w t x + \frac{W}{n}\right) \text{cosec. } \alpha = \left(\psi r w t x + \frac{W}{n}\right)\frac{r}{y}.$$

The meridional thrust per unit of horizontal circle at P, call it M, is found from this, by dividing by $\frac{2\pi y}{n} = \psi y$, to be,

$$M = \frac{r^2 w t}{y^2} x + \frac{W r}{2\pi y^2} \dots\dots\dots\dots\dots\dots (3)$$

This formula is true when P is anywhere between D and B.

The force triangle to the right in Fig. 6 indicates, by the vertical line, the load above $\left(\psi r w t x + \frac{W}{n}\right)$, supported at P, the hypothenuse is the meridional thrust at P and the base is the total horizontal thrust at $P = H$. This triangle is similar in meaning to any one of the triangles, as 0 3 3′ in Fig. 4(*b*) or 0 9 9′ in Fig. 5(*b*).

With the notation just preceding Equation (5), further on, the meridional thrust at a point $(x_1 y)$ under the lantern load is readily found, as follows:

$$\text{The vertical load at } (x_1 y) = \psi r w t x + \frac{p\psi}{2}(y^2 - y_0^2).$$

On multiplying this by cosec. $\alpha = \frac{r}{y}$ and dividing by $\psi\ y$, we find,

$$M = \left[r w t x + \frac{p}{2}(y^2 - y_0^2)\right]\frac{r}{y^2} \dots\dots\dots\dots (3')$$

At E, $x = 0$, $y = y_0$; therefore $M = 0$; at D, $(3') = (3)$.

On changing x to $x + \Delta x$ in Fig. 6, y changes to $y + \Delta y$, s to $s + \Delta s$, α to $\alpha + \Delta \alpha$ and H to $H + \Delta H$.

$\frac{\Delta H}{\Delta s}$ = average rate of increase of H per unit of meridian length,

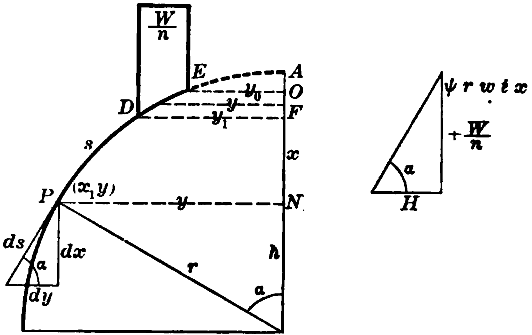

FIG. 6.

and the limit, as $\Delta\, s = 0$, is,

$$\frac{d\,H}{d\,s} = \text{rate of increase at } P \text{ per meridian unit}$$

$$= \text{intensity of } Q \text{ (Art. 2) per meridian unit, at } P.$$

From the force triangle, for points, P, below D,

$$H = \left(\psi\ r\ w\ t\ x + \frac{W}{n}\right) \cot.\ \alpha.$$

Therefore

$$\frac{d\,H}{d\,s} = \left(\psi\ r\ w\ t\ x + \frac{W}{n}\right)\left(-\operatorname{cosec.}^2 \alpha \frac{d\,\alpha}{d\,s}\right) + \psi\ r\ w\ t \frac{d\,x}{d\,s} \cot.\ \alpha.$$

$$= \left(\psi\ r\ w\ t\ x + \frac{W}{n}\right)\left(-\frac{r^2}{y^2}\,\frac{1}{r}\right) + \psi\ r\ w\ t\ \frac{y\ h}{r\ y}.$$

Therefore $\frac{d\,H}{d\,s} = \psi\ r\ w\ t\ \left(-\frac{x\ r}{y^2} + \frac{h}{r}\right) - \frac{W\,r}{n\,y^2}$.

On dividing this by $\frac{2\,\pi}{n} = \psi$, Art. 2 (1), we get the side thrust on a voussoir per unit of meridian length, or the "crown" thrust at $(x_1 y)$, when P is below D.

$$C = w\ t\ h - w\ t\ x\ \frac{r^2}{y^2} - \frac{W\,r}{2\,\pi\,y^2} \ldots\ldots\ldots\ldots\ldots (4)$$

This formula gives the intensity of the "crown" pressure (or tension), in pounds, at the point, $(x_1 y)$.

If there is no lantern, $W = 0$, and the last term drops out, giving the crown pressure for the open dome.

If the dome is closed, or complete, the points, D, and O, move to A; and x must be reckoned from the summit, A.

By the use of Figs. 4(*a*), 4(*b*), the significance of the foregoing steps will be more apparent. Thus, if we conceive the point, *P*, of Fig. 6 to be at *c*, Fig. 4(*a*), whence $s = A\ c_1$ and $H = \psi\ 1\ 1'$, Fig. 4(*b*), and that s is increased to $s + \Delta\ s = Ac_2$ (say); then $H + \Delta\ H = \psi\ 2\ 2'$; consequently, $\Delta\ H = \psi\ b\ 2' = Q_2$ (Art. 5) and $\Delta\ s = \text{arc}\ c_1\ c_2$. Hence, $\frac{\Delta\ H}{\Delta\ s} = \frac{Q_2}{\text{arc}\ c_1\ c_2}$, gives the average value of Q affecting the voussoir, $c_1 c_2$, per unit of meridian length. This changes as $\Delta\ s$ becomes smaller and approaches a limit, as $\Delta\ s = 0$, $\frac{d\,H}{d\,s}$, which is defined to be the intensity of Q per unit meridian at the point, $(x_1\ y) = c_1$, here.

If we suppose $P = (x_1\ y)$ at c_7, Fig. 4(*a*), and that $\Delta\ s = \text{arc}\ c_7\ c_8$, then $H = \psi\ 7\ 7'$, $H + \Delta\ H = \psi\ 8\ 8'$; whence $\Delta\ H = -\ \psi\ c\ 7'$ and $\frac{\Delta\ H}{\Delta\ s} = \frac{Q_8}{\text{arc}\ c_7\ c_8}$ is negative, whence its limit is negative. We conclude that when Formula (4) gives a negative value for *C*, the crown thrust, tension is exerted around the crown.

The crown pressures, as given by Formula (4) and the diagram, are not identical, the one referring to intensity at a point, the other to average stress over an area. On assuming a large number of divisions of *A C*, and taking $P = (x_1\ y)$, at the center of a corresponding voussoir, the two methods should give practically identical results.

Let us now find the crown stress at any point, $(x_1\ y)$, of the arc, *D E*, under the lantern load. As in Art. 8, let p = weight, in pounds per horizontal square foot, of the lantern, so that,

$$p = \frac{W}{\pi\,(y_1 - y_0^2)}$$

The weight of the lantern load resting on the voussoir extending from *E*, Fig. 6, to the point, $(x_1\ y)$, is thus,

$$\frac{1}{n}\, p\, \pi\, (y^2 - y_0^2) = \frac{p\ \psi}{2}\, (y^2 - y_0^2).$$

On adding the weight of the voussoir to this, and multiplying the sum by cot. α, as before, we find the total horizontal thrust exerted at $(x_1\ y)$.

$$H = [r\ w\ t\ x + \frac{p}{2}\, (y^2 - y_0^2)]\ \psi\ \text{cot.}\ \alpha.$$

Proceeding as above,

$$\frac{1}{\psi}\frac{d\,H}{d\,s} = \left[r\,w\,t\,x + \frac{p}{2}(y^2 - y_0^2)\right]\left(-\operatorname{cosec.}^2 \alpha\,\frac{d\,\alpha}{d\,s}\right) + \left[r\,w\,t\,\frac{d\,x}{d\,s} + p\,y\,\frac{d\,y}{d\,s}\right]\frac{h}{y}.$$

Therefore, $$C = \left[r\,w\,t\,x + \frac{p}{2}(y^2 - y_0^2)\right]\left(-\frac{r}{y}\right) + \left[w\,t\,y + p\,y\,\frac{h}{r}\right]\frac{h}{y}.$$

Therefore, $$C = w\,t\left(h - r^2\frac{x}{y}\right) + p\,\frac{h^2}{r} - \frac{p}{2}(y^2 - y_0^2)\,\frac{r}{y^2} \cdots\cdots (5)$$

This value of C is the crown pressure at a point, $(x_1\, y)$, on the arc lying between D and E.

At the inner edge of the lantern, E, $x = 0$, $y = y_0$, $h = C\,O$.

Therefore, C (at E) $= w\,t\,C\,O + p\,\frac{C\,O^2}{r}$.

Just above D, the outer edge of the lantern, $x = O\,F = x_1$, $y = y_1$, $h = C\,F = h_1$; therefore, from Equation (5),

$$C = w\,t\left(h_1 - r^2\frac{x_1}{y_1^2}\right) + \frac{p\,h_1^2}{r} - \frac{W\,r}{2\,\pi\,y_1^2}.$$

Just below D, from Equation (4),

$$C = w\,t\left(h_1 - r^2\frac{x_1}{y_1^2}\right) - \frac{W\,r}{2\,\pi\,y_1^2}.$$

There are thus different values for C just above and just below D, exactly as was found by the graphical method, the difference being $\frac{p\,h_1^2}{r}$. If the first value of C is positive and the second is negative, the joint of rupture is at D. If both are positive, the joint of rupture is lower down. Compare results with Figs. 5(a), 5(b).

At the base, B, $x = O\,C$, $y = r$, $h = 0$; therefore, from Equation (4),

$$C = -\,w\,t\,C\,O - \frac{W}{2\,\pi\,r}\text{ (tension)}.$$

When the origin is changed to F, the two formulas, (3) and (4), are identical in meaning with those given by E. Schmitt, Assoc. M. Am. Soc. C. E., in his paper on domes,* except for his unwarranted use of the double sign in his Equation 27; but some results are given just below his Equation 27 which do not agree with those just found.

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* *Transactions*, Am. Soc. C. E., Vol. LII, p. 270.

For a closed dome with no lantern, O is put at A, $x = A\,N = r - h$, and Equation (4) reduces to,

$$C = w\,t\,h - w\,t\,\frac{(r-h)\,r^2}{r^2 - h^2} = w\,t\left(h - \frac{r^2}{r+h}\right).$$

This is zero at $h = 0.618\,r$, corresponding to $\alpha = 51°\ 49'$. The joint at this point is called the "joint of rupture." Above this joint C is positive or in compression, below it is negative or in tension.

The hoop tension in a metal band encircling the dome at a height, h, above C, Fig. 6, is found as follows (see, also, Art. 6). Take the case of the open dome with the lantern. The total horizontal thrust at P (below D) exerted on the voussoir just below P is,

$$H = \left(\psi\,r\,w\,t\,x + \frac{W}{n}\right)\text{cot. }\alpha = \left(\psi\,r\,w\,t\,x + \frac{W}{n}\right)\frac{h}{y}.$$

Therefore, by Equation (2), the tension, T, in the band is,

$$T = \frac{H}{\psi} = \left(r\,w\,t\,x + \frac{W}{2\,\pi}\right)\frac{h}{y} \quad\ldots\ldots\ldots\ldots\ (6)$$

For the closed dome with no lantern, $W = 0$, and with O at A, $x = r\,(1 - \text{cos. }\alpha)$, $h = r\,\text{cos. }\alpha$ and $y = \text{sin. }\alpha$,

$$\text{therefore } T = r^2\,\frac{(1 - \text{cos. }\alpha)\,\text{cos. }\alpha}{\text{sin. }\alpha} = r^2\,\frac{\text{sin. }\alpha\,\text{cos. }\alpha}{1 + \text{cos. }\alpha},$$

which is Rankine's formula.* At the joint of rupture, where $\alpha = 51°\ 49'$,

$$T = 0.3\,w\,t\,r^2.$$

This is the maximum hoop tension for a spherical dome of constant (small) thickness, t.

10.—Let us discuss a little more fully the closed dome with no lantern. The origin, O, in Fig. 6, now moves to the summit, A;

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* "Applied Mechanics," p. 267.

NOTE.—To compare results with those given by Rankine for the closed dome with no lantern (the only case discussed by him), we observe that if P_x denotes the total weight of the dome to the level of $(x_1\ y)$, then, for $W = 0$, M (of Equation 8, above) $= \frac{P_x\ \text{cosec. }\alpha.}{2\,\pi\,y}$, C (of Equation 4, above) = Rankine's p_z and T (of Equation 5, above) = Rankine's P_y.

Rankine's results, expressed in trigonometrical functions, can be easily expressed in terms of x, y and h. They are found to be identical with those given by Equations (8), (4), and (6), above. The results for a truncated conical dome with a lantern, given in Art. 11, are likewise identical with those given by Rankine, when reduced as before.

whence $x = A\,N = r - h$ and $y^2 = r^2 - h^2$. Also, $W = 0$. Formulas (3) and (4) reduce to,

$$M = w\,t\,\frac{r^2}{r+h} \quad\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3')$$

$$C = w\,t\left(h - \frac{r^2}{r+h}\right) \quad\ldots\ldots\ldots\ldots(4')$$

M increases as h diminishes. Its least value, indefinitely near A, for which $h = r$, is $\frac{1}{2}\,w\,t\,r$ (compression). Its greatest value is at the base, B, for which $h = 0$, and is $w\,t\,r$, also compression. The derivative of C, with respect to h, is $\left(1 + \frac{r^2}{(r+h)^2}\right) w\,t$, a positive quantity, indicating that C increases algebraically as h increases. At the base, B, $h = 0$ and $C = -\,w\,t\,r$ (maximum tension); when $h = 0.618\,r$, $C = 0$; finally, indefinitely near the summit, A, $h = r$ and $C = \frac{1}{2}\,w\,t\,r$ (maximum compression).

The thrust, M, acts upon a conical joint the area of which is $t \times 1 = t$ square feet. Similarly, C acts upon a vertical joint of the same area, t. Whence, dividing the above values by t, the stresses, in pounds per square foot,

due to the meridional thrust at $A = \frac{1}{2}\,w\,r$, compression
" " " " " " $B = w\,r$, "
" " " crown " " $A = \frac{1}{2}\,w\,r$, "
" " " " " " $B = -\,w\,r$, tension.

These stresses represent the average stress, in pounds per square foot, over the corresponding joints. If the resultant force passes through the center of the joint, they are maximum stresses; if it passes $\frac{1}{3}\,t$ from the edge, the maximum unit stresses are double the above values. For safety, considering the elastic yielding of the dome is that whatever the thickness, t, of the shell, the unit stresses above, and perhaps more for very thin domes.

The remarkable fact concerning all unit stresses in a closed dome is that whatever the thickness, t, of the shell, the unit stresses are the same for the same radius. Increasing t does not increase the strength, unless the elastic yielding of the dome materially modifies results, by causing the resistance lines to depart so far from the centers of the joints that the unit stresses are very much increased, and even considerable tension may be caused in some of the joints.

In the present state of our knowledge, it is impossible to locate accurately these lines connecting the centers of pressure on the joints of either a crown or a wedge. Hence, it is wise to be conservative in assuming the thickness of a dome.

Reinforced concrete seems to be admirably adapted to the construction of domes. The concrete can take all compressive stresses and the steel the tensile stresses developed in the lower crowns of the dome.

For a complete spherical concrete dome, let us assume $w =$ 150 (lb. per cu. ft.), $r = 50$ (ft.); then, double the average meridional compressive stress at the base, is $2\ w\ r = 15\,000$ lb. per sq. ft. $=$ 104 lb. per sq. in. Double the average tension in the crown, 1 ft. high, resting on the base, is also 104 lb. per sq. in. A very small chain, or steel reinforcement, can take this tension without yielding appreciably under the stress. It would be risky to count on the concrete furnishing any tensile resistance.

The stresses at the summit, both crown and meridional, are compressive, and double the average is only 52 lb. per sq. in.

The stresses at the base are the maximum stresses, either crown or meridional, experienced anywhere in the closed dome, no matter what the thickness, if the assumptions are realized. Thus, if it were possible for concrete to stand a compressive stress of 104 lb. per sq. in., when of the thickness of an egg-shell, a spherical concrete-steel dome 100 ft. in diameter would be perfectly stable, if it were no thicker than an egg-shell. Of course, the assumptions are not exactly realized. The meridional and crown thrusts are rarely applied at the centers of the joints; in fact, for a very thin shell, not built perfectly true, they can easily, at some joints, not only lie outside of the middle third of the cross-section of the shell, but even outside the shell, causing tension on the opposite surface. With a thick shell, this can rarely, if ever, happen. As, in the theory of the simple (barrel) arch, the elastic yielding of the arch determines the line of the centers of pressure, so here, the elastic yielding of the dome must determine the corresponding centers of pressure, though the theory has never been formulated. For a thin metal arch, the centers of pressure may lie outside the arch, and the same thing may happen for a thin concrete dome.

If a complete theory of the dome, considering its elasticity, were known, a proper thickness could be found to satisfy both strength and stability. As it is, our present imperfect theory gives no proper answer to this question, and the thickness has to be assumed; based, to some extent, on the successful practice of the past.

It is natural to think that, since the average stresses at the base of a complete spherical dome are double those at the summit, the thickness should be greater at the base to equalize the stresses more nearly. It is well to count the extra cost before doing so.

Thus, take the complete dome already examined, where $w = 150$, $r = 50$ (ft.). The average stress at the base is 52 lb. per sq. in., and at the summit 26 lb. per sq. in. for any thickness, t. Assume $t = 1$ (ft.). Then conceive a dome having the thickness, 1 ft. at the summit and 2 ft. at the base. The radius of the intrados is 50 ft. and that of the extrados is readily found to be 52.01 ft. The volume of the dome is the difference between the volume of the spherical segment with radius 52.01 and altitude 51 and that of the hemisphere of radius 50. It is found to be 7 728 π cu. ft.

The vertical component of the thrust at the base, 7 728 $w \pi$, divided by the area of the base $= 204 \times 144 \pi$ sq. in., gives the meridional stress at the base $= 39.6$ lb. per sq. in. Since the contour curves at the summit are parallel, the stress there will be the same as for a dome of constant thickness and mean radius 50.5, or equal to $\frac{1}{2} w r = \frac{1}{2} 150 (50.05) \div 144 = 26$ lb. per sq. in., which still differs considerably from the stress at the base. Comparing results with the dome of constant thickness 1 ft. and radius 50 ft., the volume of which is 5 101 π, we see that the unit stress at the base has been decreased from 52 to 39.6 lb. per sq. in., while the volume has been increased in the ratio 7 728 to 5 101.

If we reduce the thickness at the summit to 6 in. and retain the thickness of 2 ft. at the base, the stresses at the summit and base are 26.3 and 32.7 lb. per sq. in., respectively, and the volume = 6 410 π.

The unit stresses in the dome of radius 50 ft. and constant thickness $t = 0.5$ (ft.) are 26 and 52, as before, and the volume = 2 525 π.

The stresses at the base and summit have now been more nearly equalized, by varying the thickness from 0.5 ft. at the summit to 2 ft. at the base, but the volume has been increased over that of the dome with constant thickness, 0.5 ft. in the ratio 6 410 to 2 525. The reduction in stress seems hardly worth the extra cost in either case for a dome of this size unless the maximum unit stress was ten times the average maximum 52 lb. per sq. in., or 520 (the safe compressive strength) which could only happen when the thrust was near the intrados or extrados.

The limiting radius for a reinforced concrete dome of such thickness that the center of pressure on any joint is nowhere nearer the surface than one-third the thickness, and where the maximum stress allowed on concrete in compression is 500 lb. per sq. in., is found, by equating the maximum stress, 2 (w r), with 500 × 144, to be,

$$r = \frac{72\ 000}{300} = 240 \text{ ft.}$$

In such a dome, it would certainly be advisable to increase the thickness from the summit down, for wind stresses have to be allowed for, in addition to other stresses due to fixed load. Concrete cannot always be depended on in tension, since shrinkage cracks have been known to appear. If its resistance in tension is ignored, we have another reason why the thickness of domes should not be too small; since, with a thin shell of, say, 6 in., the thrust need only move 1 in. from the center of the joint to double the stress and 2 in. from the center to quadruple the average stress, whereas, if the thickness is 12 in., the resultant on the joint would have to move double these distances to double and quadruple, respectively, the average stress. If the thrust, in either case, moved to the extrados or intrados (and still ignoring the concrete in tension), the stress would be infinite and the concrete would crush.

What would become of our "egg-shell" dome with a movement of the thrust only one-half the thickness of the egg-shell?

Such considerations go to show the theoretical necessity for having a dome of appreciable thickness.

If the thickness of the dome is varied, the graphical method, hitherto given, affords a ready solution; but now the successive weights to be laid off along the vertical load line are not equal for equal altitudes, as before. The construction and final results are otherwise as given in Articles 3-8. It will suffice to describe the center line of the meridional section of the half dome with a radius, r, found by trial, having its center on the axis of the dome. Then, as in Art. 3, the weight of a voussoir will be $\psi\ r\ a\ w\ t$, approximately, where $t =$ mean thickness of the voussoir. A large number of divisions should be used to cause the total volume to agree with that computed, as in the examples of this article. The meridional thrusts are, as before, drawn perpendicular to the radii of the center line at the points, c_1, c_2, etc.

11.—Truncated Conical Dome Supporting a Lantern of Weight, W.—Let Fig. 7 represent half a meridional section of the dome, c_0c_4, supporting a cylindrical lantern at the top, c_0. The intersection of the center line, c_0c_4, with the vertical axis of the dome is at O, the angle between these two lines is α, and O, being taken as the origin, x vertical and y horizontal, the co-ordinates of c_0 will be called (x_0, y_0) and of any point, c, (x, y) with the proper subscripts.

Divide the altitude of the dome into any number of equal parts (only four in the figure—a much larger number is desirable) each of height a feet, and pass horizontal planes through the points of division, cutting the dome at c_0, c_1, c_2.....Call the horizontal radius of the point midway between c_1 and c_2, r_2, the horizontal thickness of the shell t (both in feet), then, by the law of Pappus, the volume of the voussoir, c_1c_2, included between the two meridian planes making an angle, $\psi = \frac{2\pi}{n}$, with each other, is $a\ t\ r_2\ \psi$, and if w is the weight of the dome per cubic foot,

$$\text{the weight of the voussoir, } c_1c_2 = w\ a\ t\ r_2\ \psi$$

and similarly, for the weight of any voussoir. These weights vary with r.

The weight of the lantern contained between the two meridian lanes is $\frac{W}{n} = \frac{2\pi}{n} \cdot \frac{W}{2\pi} = \psi \frac{W}{2\pi}$.

The construction and interpretation of the force diagram is so similar to that given for the spherical dome (Arts. 8, 3, 4, 5, 6) that reference to preceding articles will sufficiently explain the successive steps below.

In the force diagram, Fig. 7, lay off $A\ 0 = \frac{W}{2\pi}$ vertically; then $0\,1 = w\ a\ t\ r_1$ for the voussoir, $c_0 c_1$; $1\,2 = w\ a\ t\ r_2$ for the voussoir, $c_1 c_2$, etc.; whence the actual weights are, in turn, $\psi\ A\ 0$, $\psi\ 0\ 1$, $\psi\ 0\ 2, \ldots$, and the measures of all lines in the force diagram must be multiplied by ψ to give correct results.

Assuming, as for the spherical dome, that the meridional thrust at any point is tangent to the center line of part of the shell included between the two meridional planes making an angle, ψ, with each other, it is seen here that the meridional thrusts act along $c_0 c_4$. Hence, draw $A\,4'$ parallel to $c_0 c_4$ and through the points, $0, 1, 2, \ldots$, draw horizontals meeting at $A\ 4'$ at $0'\ 1', 2', \ldots$.

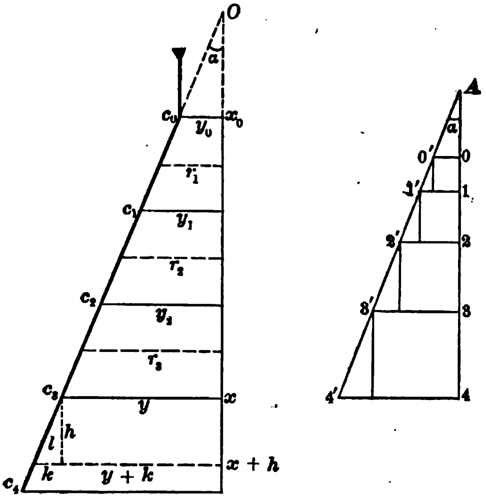

FIG. 7.

It follows that the meridional thrusts at $c_0, c_1, c_2, \ldots$, are exactly $\psi\ A\ 0'$, $\psi\ A\ 1'$, $\psi\ A\ 2', \ldots$; whence the meridian thrusts per unit of length of horizontal circle through $c_0, c_1, c_2, \ldots$, are found by dividing these values in turn by $\frac{2\pi y}{n} = \psi y$, the horizontal width of the voussoir at the point, and are, respectively,

$$\frac{A\ 0'}{y_0} \text{ at } c_0, \frac{A\ 1'}{y_1} \text{ at } c_1, \frac{A\ 2'}{y_2} \text{ at } c_2, \ldots.$$

Also, as in Art. 6, the hoop tensions at c_0, c_1, c_2, ..., are 0 0′, 1 1′, 2 2′, ..., respectively.

The horizontal radial force exerted on the voussoir, c_4, c_3, is evidently (see Art. 3) $Q_4 = \psi\,(4\,4' - 3\,3')$; and similarly for the others.

Call the lengths, $c_0c_1 = c_1c_2 = c_2c_3 =$ etc. $= s$; then the average side thrust on the voussoir, c_4c_3, per foot of meridian (see Art. 2), $c_4 = \frac{q}{s} = \frac{Q}{\psi s} = \frac{4\,4' - 3\,3'}{s}$; or, generally, if we designate the horizontal projections of 0′ 1′, 1′ 2′, 2′ 3′, ..., by b_1, b_2, b_3, ..., respectively, the average side thrust on the voussoirs, c_0c_1, c_1c_2, c_2c_3, ..., per foot of meridian, will be, $\frac{b_1}{s}$, $\frac{b_2}{s}$, $\frac{b_3}{s}$, ..., respectively.

12.—Analytical Solution for the Truncated Dome with a Lantern of Weight, W.—The thickness of the shell, t, will now be taken at right angles to c_0c_4, and the weight of the dome will be regarded (for t small) as equal to the area of the convex surface of the frustum multiplied by $w\,t$. Let the co-ordinates of any point, c_3, be (x, y) and let the length, $O\,c_3 = s$, $O\,c_0 = s_0$, whence the weight of the entire dome above the point, (x, y), is,

$$\left(2\,\pi\,y\,\frac{s}{2} - 2\,\pi\,y_0\,\frac{s_0}{2}\right) w\,t.$$

Therefore the total weight of $\frac{1}{n}$ the dome above (x, y) and $\frac{1}{n}$ the lantern is,

$$w\,t\,\frac{\psi}{2}\,(y\,s - y_0\,s_0) + \frac{W}{n}.$$

From the force triangle, $A\,3\,3'$, where $A\,3$ may now be taken for this weight, the meridional thrust, $A\,3'$, equals,

$$\left[\frac{w\,t\,\psi}{2}\,(y\,s - y_0\,s_0) + \frac{W}{n}\right] \sec.\ \alpha;$$

whence the meridional thrust, per foot of horizontal circumference, is this expression divided by $\frac{2\,\pi\,y}{n} = \psi\,y$, or,

$$M = \left\{\frac{w\,t}{2}\,(y\,s - y_0\,s_0) + \frac{W}{2\,\pi}\right\}\frac{s}{x\,y} \quad \text{..............} (7)$$

As in Art. 6, the hoop tension at (x, y) is $\frac{3\,3'}{\psi}$, or,

$$T = \left\{ \frac{w\,t}{2}(y\,s - y_0\,s_0) + \frac{W}{2\,\pi} \right\} \tan.\,\alpha =$$

$$\left\{ \frac{w\,t}{2}(y\,s - y_o\,s_o) + \frac{W}{2\,\pi} \right\} \frac{y}{x} \,\ldots\ldots\ldots\ldots\ldots\ldots \text{(8)}$$

To find the thrust around the horizontal crown at (x, y), let us conceive x, y and s to take the simultaneous increments, h, k and l; the total weight now supported at the point, $(x + h, y + k)$, is,

$$\frac{w\,t\,\psi}{2} \left\{ (y + k)\,(s + l) - y_0\,s_0 \right\} + \frac{W}{n}.$$

On developing and subtracting from this the weight supported at (x, y) given above and multiplying by tan. α, to get Q = radial horizontal thrust acting on the voussoir of length l, we find,

$$Q = \frac{w\,t\,\psi}{2} \left\{ k\,(s + l) + y\,l \right\} \tan.\,\alpha.$$

By Art. 2, the side thrust on the vertical face of the voussoir lying between (x, y) and $(x + h, y + k)$ is $q = \frac{Q}{\psi}$, and, dividing this by l, we get the average side thrust per foot of meridian length. As h, k and l simultaneously approach zero, this expression approaches a limit, C, which is defined to be the intensity of the pressure all around the crown at (x, y) per meridian unit. Therefore, as l and k tend indefinitely toward zero,

$$C = \lim.\,\frac{Q}{\psi\,l} = \lim.\,\frac{w\,t}{2} \left\{ \frac{k}{l}\,(s + l) + y \right\} \tan.\,\alpha,$$

$$\text{or, } C = \lim.\,\frac{w\,t}{2} \left\{ \frac{y}{s}\,s + y \right\} \tan.\,\alpha = w\,t\,\frac{y^2}{x} \,\ldots\ldots\ldots\ldots \text{(9)}$$

The formulas for C and M reduce to those given by Professor Church* for the complete dome with no lantern.

This is not equal to the average side thrust on the voussoirs just above or just below (x, y), but when the lengths of these voussoirs are very small, it approximates the mean of these two side thrusts. Or, put another way, if (x, y) is a point at the middle of any voussoir, the value of C above should give a close approximation to the side thrust on that voussoir as found graphically in Art. 11, provided the length of the voussoir is small enough.

The above values for M, T and C are correct for any point, (x, y), at or below c_0. It is to be remarked that Equation (9) is always positive and independent of W; hence C is always in compression and has the same value for a dome with or without a lantern.

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* *Transactions*, Am. Soc. C. E., Vol. LII, p. 314, 70(a), 71(a).

If the abutment cannot withstand the horizontal component of the meridional thrust there, a metal hoop must be placed around the base of the dome. The tension to be provided for in it is given by Equation (8), when x, y and s are given the values pertaining to c_4, Fig. 7.

It is seen from the foregoing that, in a conical dome, the base of which is kept from spreading, either by aid of friction on a firm abutment, or by means of a hoop, tension is nowhere exerted from the summit down. It is thus admirably adapted to masonry construction and to sustaining a heavy weight, as that of a lantern, at the summit. St. Paul's, London, is a novel illustration of the use of a conical dome to sustain the weight of a stone lantern, but having also "an inner dome, visible in the church, of brick 18 in. thick, except near the bottom, where it grows out of the cone of the same thickness, going up outside it." "Outside the cone is built a wooden dome covered with lead." This evidently gives a very strong construction.

A heavy lantern on a spherical dome, not only adds greatly to the stresses, but, in addition, it moves the joint of rupture much nearer the summit, thus causing more crowns to suffer tension, or, for the masonry dome which cannot take tension, the part below the joint will tend to separate into a series of simple arches. Assuming these simple arches to be each contained between two meridian planes, the line of resistance is drawn from the joint of rupture downward with the meridional thrust acting there and with its horizontal component as the constant horizontal thrust.

As stated in the beginning, it is not the intention of the writer to enter into a full discussion of the stone or brick dome. The reader will find in Professor H. T. Eddy's "New Constructions in Graphical Statics"* some interesting constructions and reflections concerning masonry domes, particularly as to the simple arch action referred to.

The writer's views are given in his "Theory of Steel-Concrete Arches and Vaulted Structures," where the dome of varying thickness is discussed, and the dome with two shells, bearing a lantern load, receives a graphical treatment.

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* D. Van Nostrand Co., publisher.

It is not the intention of the writer to go further in the subject of domes, but it may be added, in conclusion, that domes of revolution of any kind, as well as framed polygonal domes, are easily treated by the graphical method.

Vol. XXXI. APRIL, 1905. No. 4.

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INSTITUTED 1852.

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TECHNICAL METHODS OF RIVER IMPROVEMENT, AS DEVELOPED ON THE LOWER MISSOURI RIVER BY THE GENERAL GOVERNMENT FROM 1876 TO 1903.

Discussion.*

By Messrs. Samuel H. Yonge, H. M. Chittenden and L. J. Le Conte.

Mr. Yonge. Samuel H. Yonge, M. Am. Soc. C. E. (by letter).—The writer congratulates Mr. Fox, his colleague for twenty-one years on Missouri River work, on his admirable paper describing the works for improving that stream, and believes that his efforts in bringing the subject to the attention of this Society will meet with its commendation. The part of the paper relating to later experimental work with "bank-heads," conducted on the lower reaches of the Missouri, principally after the writer had severed his connection with work on that river, is very interesting, although the experiment was interrupted before being concluded.

The improvement of the Missouri is probably the most interesting river work ever undertaken, and there is no other river on which so many physical data have been collected—excepting the Lower

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* This discussion (of the paper by S. Waters Fox, M. Am. Soc. C. E., printed in *Proceedings* for January, 1905), is printed in *Proceedings* in order that the views expressed may be brought before all members for further discussion.

Communications on this subject received prior to May 27th, 1905, will be published subsequently.

Mississippi, which is, in fact, a lower reach of the Missouri—and such diverse and extensive experimentation conducted, with novel and original methods of improvement. There are few great rivers, if, indeed, there is another, in which various fluvial phenomena develop so rapidly as in the Missouri. Its regimen is in a condition of perpetual transition, and changes, for the consummation of which, in the majority of other non-tidal rivers, indefinitely long periods are required, in it are fully wrought within a few days. For this reason, it is one of the best subjects for the student of river physics and hydraulics, although, on account of the complexity of its phenomena, it is sometimes difficult to connect visible effects with their obsure causes. Mr. Yonge.

When improvement work was begun by the General Government, in 1878, there was available practically no literature applicable to the subject, excepting accounts of experimental works of narrow scope on East Indian rivers; reports of the construction of several bridges crossing the river, relating principally to piers and foundations, and incidentally to the materials now filling the ancient channel; and of the limited experience of the General Government on the Mississippi in the vicinity of St. Louis, Mo.

During the early years of the improvement of the river, the large expenditures made by railroad and bridge companies for protecting their properties from the river's encroachments, by means of stone spurs and revetments, increased the river's bad reputation, and caused it to be generally regarded as incorrigible and unconquerable, except by using methods of "main strength." In one instance it is stated that a railroad company protected a stretch of bank, about 200 ft. long, contiguous to its track, by the daily expenditure of a train load of stone, for a period of three months (estimated at upward of 4 500 tons). This method—even had its adoption seemed advisable, which was not the case—was, on account of its cost, beyond the reach of those in charge of Government works, who, during the operations of the first few years, in consequence of the stint of appropriations made by Congress, had their ingenuity taxed to the utmost to construct works for protecting extended areas, with entirely inadequate means.

A knowledge of the failures and successes of Missouri River improvement works, outside of the localities where they were situated, is almost entirely confined to the few who were engaged in the undertaking, or those who have read the reports of the Engineer Officers and their assistants in charge of the improvements, published in the Reports of the Chief of Engineers, U. S. Army.

In the summer of 1879, the writer first introduced on Missouri River work, at Vermilion, S. Dak., the continuous woven mattress for protecting caving banks. The Vermilion mattress, 1 125 ft.

Mr. Yonge. long, was woven down the graded bank slope and over the channel, without a boat or supporting float, with a width of about 40 ft., and was then sunk with stone ballast.

As the plan of constructing woven mattress over the water without extraneous support did not give promise of the best results, a small flat, carrying light launching ways, was devised for constructing, in 1879, near Sioux City, Iowa, the second Missouri River mattress of the above type, which was about 2 000 ft. long, and was woven and sunk in one section, at a net cost of about $2 300. The use of the boat resulted in economizing both time and money, and in producing a better mattress. On account of the small appropriation for the Sioux City work, the mattress could be made only 40 ft. wide over the water and 30 ft. on the upper bank.

The superiority of the woven mattress, for protecting banks subject to sudden change of shape from scour, on account of its flexibility; for shielding a sandy bed from the current, on account of its density and thickness, and having, withal, considerable inherent strength, caused it to be at once used at other river points where, in some cases, other types of mattress had failed in the first year's trial.

In 1885, the continuous woven mattress was adopted by Major (now Colonel) Charles R. Suter, Corps of Engineers, U. S. Army, President of the Missouri River Commission, M. Am. Soc. C. E., as part of the standard Missouri River revetment, and continued to be used as such on all revetment work constructed under the Commission until that organization was abolished by law, on June 13th, 1902. It is still used for local improvements on the river above Sioux City, Iowa. It also became the standard type of foot-mattress for protecting permeable dikes against scour, and was used to some extent for screen work, supported on pile frames, for closing chutes. Fig. 1, Plate XXXV, exhibits a coarse woven mattress used for the latter purpose. It was 50 ft. wide, and was successfully woven and sunk in a very swift current. Its purpose was to make possible the construction of a dam, about 200 ft. below the screen, in water about 25 ft. deep.

The plan of protecting the bank above low water with woven mattress on which stone was laid was not entirely abandoned until about 1887.

Green willow withes are most suitable for mattress weaving, although dogwood and saplings of other varieties can be made to serve that purpose. In weaving upper-bank mattress, the withes are stuck into the bank slope.

The following is a description of the process of weaving subaqueous mattress. The illustrations, Figs. 2, 3, 4 and 5, Plate XXXVI, are from photographs of rude models, for conveying an idea of the steps of the process, but not of the product.

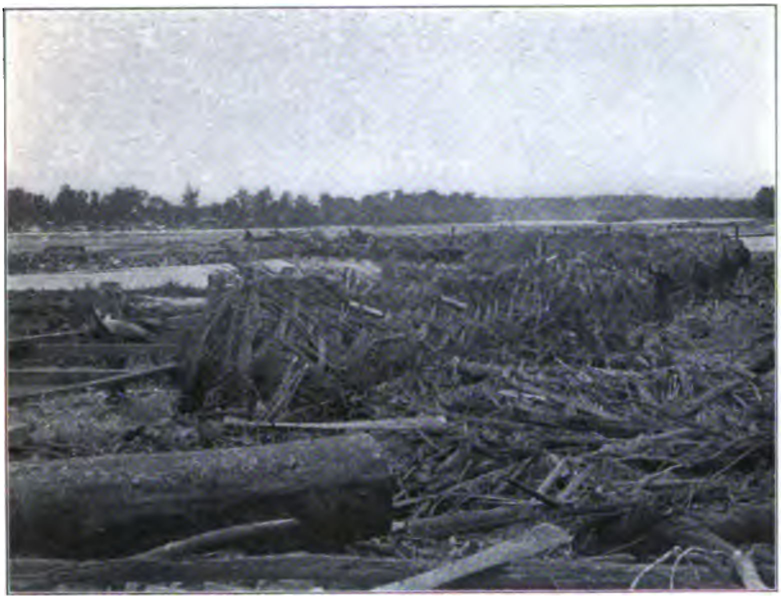

FIG. 1.—COARSE WOVEN MATTRESS DIKE SCREEN.

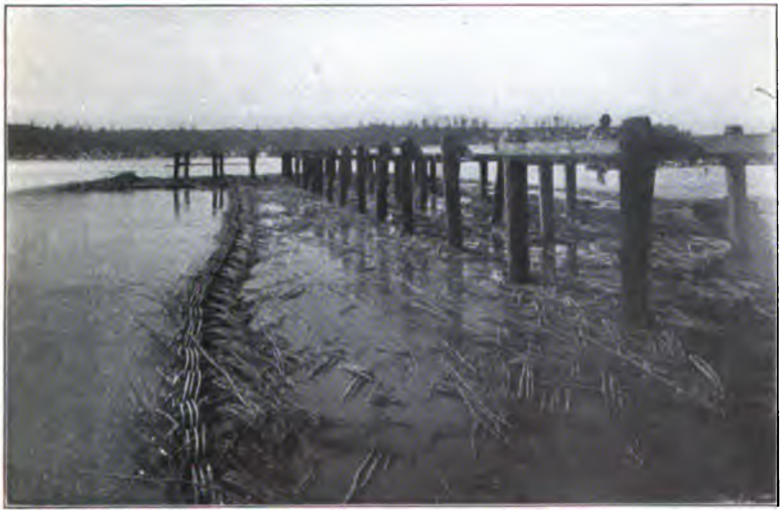

FIG. 2.—LONGITUDINAL WITHES IN SELVAGE OF WOVEN MATTRESS.

Mr. Yonge. The weaving can be started either by sticking withes into the toe of the bank and weaving out over the mattress-boat ways, a selvage, described below, being formed across the head of the mattress; or by laying across and lashing temporarily to the ways a long fascine of 8 or 9 in. diameter, to serve as a header and hold the first two or three series of withes. The latter plan, the one usually followed, is incorporated in the description.

Through the fascine, the first series of pairs of diagonal withes are thrust so as to stand at an angle of elevation of about 40° and have their included angles at the fascine about 70 degrees. The diagonals are then worked over and under each other at their alternate intersections, forming a loose, rough network of diamond-shaped meshes about 14 by 10 in. (see Fig. 2, Plate XXXVI). A second series of pairs of withes is then thrust through the fascine, approximately parallel to those of the first series, and bisecting the first line of meshes. If the withes are small, or a close mattress—generally a desideratum—is to be made, a third series of withes is stuck through the first line of meshes into the fascine, though not so shown on Fig. 4, Plate XXXVI, reducing still further the spaces of the initial meshes. The fourth series of diagonals is then thrust through the second line of original meshes, so as to reach under the fascine. Next follows the fifth series, the members of which are thrust through the third line of original meshes, or about 14 in. behind the fourth series of diagonals, so as to extend about 2 or 3 ft. under the completed weaving. The weaving is proceeded with by sticking each succeeding series of diagonals about a mesh's length back of the preceding series.

If it is desired to thicken the mattress, the distances between the lines of the series of diagonals are reduced, and contrariwise. The angles with which the weaving was started are approximately observed throughout the process.

Simultaneously with the placing of the second series of diagonals, the first stitch or loop of the selvage is formed by sticking one or more small withes, herein referred to as selvage withes, through the outer corner mesh of the mattress and through the fascine. These withes are then bent around and lashed to one or more diagonals of the first series. The butt ends of withes for the second loop are passed under the first loop and through the fascine, and the brush ends are bent down and around and lashed to a diagonal. Each succeeding loop is formed by sticking the butt ends of the selvage withes along the outer side of the selvage—6 to 10 in. apart—first under the preceding loop, then over the loop back of the preceding one, and finally under the completed weaving, the tops being bent over, turned in and lashed to the diagonals, as already described. The selvage is thus made up of a series of intersecting scallops, each

Mr. Yonge. of which crosses the preceding one at about its middle, the butt ends of the withes being held by the preceding scallops and the diagonals in the body of the mattress, and the brush ends by lashings and the weaving in contact with them above and below.

Fig. 5, Plate XXXVI, is intended to show the weaving of the selvage. The weaving thereon shown for the body of the mattress does not accord strictly with the method described.

As the weaving of the selvage proceeds, the parts of most of the diagonals protruding beyond it are made to form a part of it by turning them in with the selvage withes. If the weaving of the body of the mat is close, the selvage withes are sometimes omitted, the protruding ends of the diagonals taking their place. The selvage is also generally thickened and reinforced by weaving withes into it longitudinally, parts of the longitudinals being covered by the turned-in ends of the diagonals and selvage withes.

After several lines of meshes in the body of the mattress are woven, the withes are held down by the weavers sitting on their free ends. Care must be exercised to have the parts of the mattress made by contiguous weavers properly united.

Although the general appearance of the completed mattress is symmetrical, the meshes are not of uniform size. This, however, is not essential. It results, to a great extent, from the withes being of different sizes.

An important requirement is that of thrusting each withe 2½ ft. or more under the completed weaving. In this type of mattress each withe is under strain, binding the preceding ones and being bound by those that follow. It is next to impossible, without breaking it, to pull a withe from a completed mattress.

Before sinking the mattress the fascine header should be well lashed to the adjacent weaving with galvanized-iron wire.

This type of mattress is used nowhere except on the Missouri. It differs radically from the types used on the Mississippi, in which the basis of strength consists of wire net, cable, or iron rods. In the woven mattress the strength is derived, in great measure, from the resilience of the bent withes.

A few weeks' practice will make proficient weavers. An average 8-hour day's work for a weaver is about 800 sq. ft., for which from 5 to 5⅝ cords of willow brush, delivered in bundles, are required for mattress about 12 in. thick.

Fig. 2, Plate XXXV, which is a view of part of a dike-mattress afloat, furnishes an example of longitudinal withes in the selvage. Fig. 1, Plate XXXV, shows the selvage without this reinforcement.

In 1887 the writer experimented with an upper bank protection of stone rip-rap without mattress, covered with quarry spalls.* This

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* Annual Report of the Chief of Engineers, U. S. Army, 1888, Part 4, p. 2265.

PLATE XXXVI.
PAPERS, AM. SOC. C. E.
APRIL, 1905.
YONGE ON
MISSOURI RIVER IMPROVEMENTS.

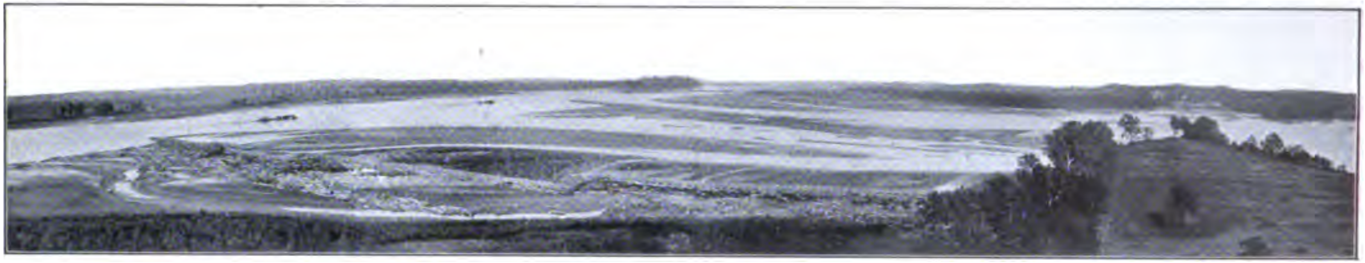

FIG. 1.—PANORAMIC VIEW OF MISSOURI RIVER AND PERMEABLE DIKES.

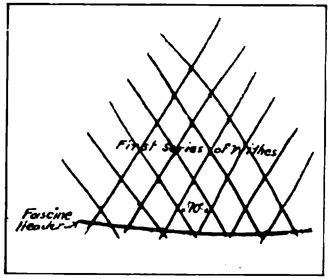

FIG. 2.

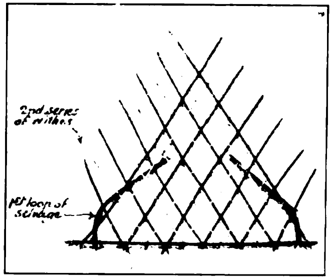

FIG. 3.

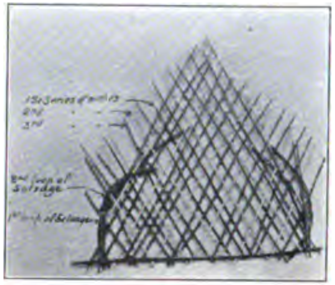

FIG. 4.

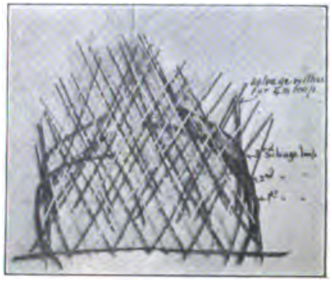

FIG. 5.

MATTRESS WEAVING.

Mr. Yonge.

detail was adopted for the later revetments constructed under the Commission. The writer, however, used spalls or macadam both under and over the stone paving. He prefers the former to the latter order, as the smaller stone is thereby prevented from being swept away by moving ice or swift currents, and in that position also thoroughly shields sandy bank slopes from the "suck" of the waves. The writer, about three years ago, successfully adopted a

SKETCH SHOWING APPLICATION OF STRAND STAYS FOR SUPPORTING DIKE FOOT-MATTRESS WHILE BEING WOVEN AND BALLASTED.

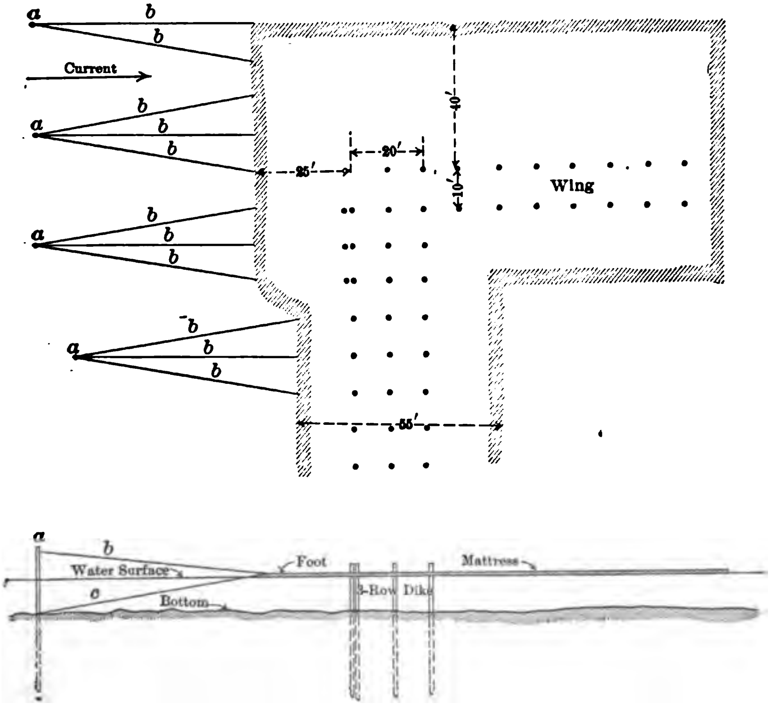

FIG. 6.

somewhat similar plan in the construction of an inclined sea-wall, formed of concrete blocks with open joints, laid on a backing of broken stone, covering an earth embankment.

The last paragraph under the caption "Foot-mattress," on page 58* of the paper, refers to the placing of anchor piles (to receive wire strand stays for mooring the foot-mattress while being woven and

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* *Proceedings*, Am. Soc. C. E., for January, 1905.

Mr. Yonge. partly ballasted). The stays referred to are marked *b* on Fig. 6, and are referred to below as surface stays. They were attached at one end to the anchor piles, *a*, at 2 ft. or more above the water, the other ends being made fast along the up-stream edge of the mattress at intervals of 10 to 15 ft. The office of the stays was to prevent the part of the mattress between its up-stream edge and the dike piles from bagging, especially while being ballasted, and then being folded by the current and carried against the dike piles. Experience soon showed that where the current was very swift the surface stays alone were not always sufficient to insure the sinking of the mattress, so as to lie even on the bottom. At some of the dikes on the Osage Division of the first reach, therefore, where the conditions for mattress sinking appeared to be unfavorable, additional stays, marked *c* on Fig. 6, and referred to as ground stays, were used. These were attached to the anchor piles by a bight, made at their ends, which was forced down the pile to the ground.

On the completion of the weaving and the placing on the mattress of sufficient stone to start its sinking, the surface stays were cast off. The ground stays, meanwhile, prevented the mattress from being rolled and torn by the current while sinking to the bottom, after which the ballasting was completed.

The double system of stays was also used in sinking revetment mattress when the weaving of a section was started in a swift current. The anchor piles were given moderate penetrations, and were generally scoured out. Those in the navigable channel were broken off below the ground by the use of a steamboat.

The objection to using solid spur dikes for the improvement of the Missouri and other rivers of its class, referred to in the beginning of this discussion, arises from the effects of the head resulting from stream impact. The initial effect is a rapid flow around the stream end of the spur, varying in intensity and extent with the head, and producing vortical action above and below the spur.

In consequence of the swift current around the spur, heavy scour occurs, resulting in the formation of a gorge section, toward which the flow lines converge, the flow finally becoming a contracted vein. Meanwhile, the adjacent banks, above and below, are attacked by vortical flow and are undermined.

The scour in front of the spur, and also on its sides, causes the mass of stone to settle indefinitely, the downward movement being aided by the weight of the spur on the saturated sandy bottom. This subsidence is not checked until a material is reached which will resist scour, usually bed-rock. The adjoining banks recede, because of undermining, until they attain a condition of comparative stability, the extent of the recession depending principally on the distances between consecutive spurs, their projection from the bank, and the angle or direction of flow.

While the above-described forces operate, the spurs must be kept built up and extended shoreward by greater or less expenditures of stone, if they are to be preserved and their severance from the bank prevented. **Mr. Yonge.**

The final result, if the maintenance of a series of spurs is persisted in, is the creation of a deep, tortuous, narrow channel, with a high velocity, beset with cross-currents and eddies, in navigating which, except possibly at low stages of water, the skill of the pilot is put to the test to save his boat from disaster.

Assuming that the distances between spurs are diminished, the above objectionable conditions are correspondingly modified, and they finally disappear when the bank protection becomes continuous, maintaining a channel of approximately uniform depth and velocity. The only valid objection to a stone revetment, maintained until stable, is its great cost. During the three years ending with 1870 the river bank in the bend between the Hannibal and St. Joseph Railroad Bridge and the mouth of the Kansas River was protected by a revetment of rip-rap, to make permanent the channel approach to the bridge draw span. The cost of the work, including its maintenance, is estimated by Octave Chanute, Past-President, Am. Soc. C. E., who was the Chief Engineer of the bridge, not to have exceeded $100 000. The length of bank protection is also estimated by Mr. Chanute at about 8 300 ft.

There will be great variation of cost of stable stone revetments, depending principally on local physical conditions.

For a free sandy bank greatly exposed to the current, impinging even at a small angle, with bed-rock at a depth of about 60 ft. below low water, the expenditure of stone required to bring the work to a condition of stability would probably amount to 50 cu. yd. per lin. ft. of bank.

The protecting influence of a solid spur does not generally extend down stream more than three or four times its normal projection from the bank, and to this extent only when the projection is sufficient to keep the area of vortical action at some distance from the bank. The protection afforded by spurs of slight projection, as has been pointed out, is to a great extent negative.

If spurs are flanked by the stream, they obstruct the channel and thus hasten the erosion of the bank they were designed to protect, and finally either disappear in the sands of the river, or, if their subsidence ceased before they were detached from the bank, they in due time form part of the extension of the opposite shore. Several examples of solid spurs, constructed by corporations, being flanked by the river came under the writer's observation while the improvement of the Missouri by the General Government was in progress, a description of one of which follows.

Mr. Yonge. In 1898 the writer found and identified on the convex side of Belmont Bend one of three spur-dikes placed on the concave side of the bend in or about 1872, to arrest the erosion which it was apprehended would terminate in the formation of a cut-off through the peninsula formed by the windings of the river, and thus render valueless the recently constructed St. Joseph and Grand Island Railway Bridge, which joined the peninsula to the opposite shore below the bend. In 1881 the spurs were flanked by the river, and the bank to which they had been attached receded about 1 500 ft., until held, in 1891, by Government revetments.

As the protective zones of short revetments and solid spurs are very restricted, they cannot be used successfully in a general scheme for improving a river with sandy banks, if bank protection or channel regulation are the ends to be attained. The most effective protection for the former purpose is a stable continuous revetment; for the latter, either a continuous revetment or a properly designed system of permeable dikes, made permanent by proper protection at their stream ends, in which the objectionable vortical action incidental to solid spurs is greatly lessened by the flow through the screen work.

The foregoing remarks as to the use of solid spurs are intended to apply solely to rivers with sandy, or other very friable banks.

Permeable dikes with curved stream ends are more costly than straight dikes, and have the serious disadvantage of inducing a rapid flow along their upper face, which prevents the formation of battures above them. Those constructed did not prove to be superior to straight dikes in resisting the forces to which dikes of both forms were subjected.

On page 54* Mr. Fox states:

> "The practice, as to height of dikes, differed on the two divisions, and varied from time to time; but, in the main, they were run out level with the top of the bank, or 2 ft. above standard high water, to near the standard high-water contour of the proposed rectified shore, and from there they sloped down to as near 2 ft. above standard low water as the stage of river at the time permitted."

In designing the dikes for the upper division (Osage) of the first reach, their inshore ends were fixed at, or slightly below, standard high water, or at the same elevation as the bank, if it was below the above reference plane. The main banks on the Osage Division are generally slightly above standard high water. Variation of dike profile was tried, to discover, if possible, whether one form possessed any advantage over another, a dike's crest sometimes being given a uniform inclination throughout, or some parts were made horizontal and others inclined. A rule almost invariably observed, however, in planning the dikes, was to place their crests so that the area above them to standard high water, with the area below the same plane in the proposed rectified channel, *i. e.*, between a pair of opposite dikes, or between a single dike and the opposite shore, together with the area which could reasonably be expected to result from scour, would be adequate for passing, at a normal velocity, the discharge for a stage of standard high water. The range between standard low water and standard high water was determined to be 13.8 ft., and the low-water width and channel areas required for discharge at the above stages, obtained by observation of natural, approximately stable reaches, were determined as about 1 000 ft., 9 000 sq. ft., and 40 000 sq. ft., respectively. Mr. Yonge.

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* *Proceedings*, Am. Soc. C. E., for January, 1905.

For a straight reach with an ideal parabolic section, the maximum scour at mid-section entailed by the above estimate would have been 15 ft., and the total center depth at the higher stage 42.3 ft.

Examples of the river's channel enlargement under contraction were not wanting to show that the estimated increase of area required in the projected rectified channel, estimated at about 10 000 sq. ft., would be realized. A part of this enlargement, varying within wide limits, is acquired, in the unimproved parts of the river, during every flood and lost by fill-back as the stage declines. On some parts of the Osage Division the old channel was closed and an entirely new channel formed, the river being first trained to initiate the excavation of the new channel through the medium of the dikes, and then forced, by the use of additional similar dikes, to enlarge it. As the dikes were permeable, the extent to which at first they reduced the channel section was considerably less than assumed in the calculation, *viz.*, the polygonal areas of their side elevations. The contracting effect for causing channel scour also increased gradually as the battures formed, and built up by deposition, the battures in due time becoming the real factors in perpetuating the regulation begun by the dikes.

During the first two or three years of the work the proposed enlargement of section progressed satisfactorily, and the indications were favorable for the attainment of the desired enlargement as soon as the battures should be fully formed. There are no published data showing the extent to which the high-water section on the Osage Division was finally developed.

To avoid a too sudden channel contraction, the dikes were not always at once constructed for their proposed full length. An interesting illustration of this feature is exhibited by Fig. 1, Plate XXXVI, showing a group of dikes designed to rectify a part of what was known proverbially as the worst reach of the river. The total projection from the (right) bank of the dike in the foreground is about 1 700 ft. It was constructed in five sections, one or more floods occurring in the intervals between the extensions. The period

Mr. Yonge. covering the dike's construction was about 27 months; the actual time of its construction was less than 2 months.

It will be noticed that the continuity of the pile structure is broken by four offsets separating the several extensions. The offsets were made to avoid the pot-hole scoured at the end of each section after its construction, the crossing of which would have required very long piles and made the exposure of the piles above ground too great to resist overturning by the pressure of the current transmitted through the accumulation of drift-wood above the dike.

It will be of interest to mention that this dike, in conjunction with several others above it and on the opposite bank, effected a very remarkable change of position of the main channel, which, before the improvement was begun, followed the right bank to the vicinity of the site of the dike, where it divided, one part flowing to the right around the point to the Osage River, the other crossing a middle ground or reef to a secondary channel following the left bank. The latter was the channel generally used by steamboats, and the depth on the middle reef was sometimes only 30 in.

The width of the river between banks is about 3 600 ft. The view shows the improvement in a state of forwardness, the flow being concentrated in a channel about 1 050 ft. wide, with a least depth of 6 ft., although the battures, especially those adjacent to new dike work, were not fully formed.

Mr. Chittenden. H. M. CHITTENDEN, M. AM. SOC. C. E. (by letter).—This paper is of particular interest, not only because of its merit as a contribution to the science of the improvement of navigable waterways, but because it marks the close of an important chapter in the history of inland navigation in the United States. The Missouri River, both in its physical characteristics and in its commercial history, is one of the remarkable streams of the world. It is a large stream absolutely, though a small one considering the area of its water-shed. The extreme flood discharge of the Ohio River at its mouth is probably about 5 cu. ft. per sec. per sq. mile of water-shed, while that of the Missouri barely reaches 1.5 cu. ft. At Sioux City, where the river may be considered as emerging from the arid and semi-arid region into the humid region, the extreme low-water flow in the dead of winter, when the tributaries are nearly all ice-bound, is about 7 000 cu. ft. per sec.* The maximum discharge at the same point is that of 1881, which is estimated at more than 600 000 cu. ft. per sec. At the mouth of the river the discharge probably falls as low as 15 000 cu. ft. per sec. in winter, and is believed to have reached approximately 900 000 cu. ft. per sec. in the great floods of 1844 and 1903.

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* As measured under the direction of the writer on February 16th, 1905, after a protracted cold spell of nearly two months over-spreading the greater portion of the water-shed.

Mr. Chittenden.

The length of the river from its extreme source at the head of Jefferson Fork to its junction with the Mississippi is 2 945 miles; and to the mouth of the latter stream 4 221 miles—the longest river in the world. More remarkable than its actual length, however, is the great length of its navigable channel, which is 2 316 miles from the extreme point reached by steamboats near the Great Falls of the Missouri to the mouth of the river, and 3 592 miles to the Gulf of Mexico. Perhaps most interesting of all is the fact that the river in its natural condition, without any artificial improvement whatever, was navigable for steamboats over all this distance. During the entire period of its greatest use as a navigable waterway the Government did almost no improvement work upon it. The river was, in fact, practically an inclined plane, without sensible interruption by cascade or rapid, rising on a gentle but gradually increasing slope (less than 3 in. per mile at high water near the Gulf to more than 3 ft. near the Great Falls) until it attained an altitude at the head of navigation of more than one-half mile above the level of the sea.

Still another remarkable fact, to those unacquainted with the history of this river, is the extent to which it has been utilized in commercial navigation. The period of its use for this purpose is now nearly, if not quite, 200 years, and it has been navigated by steamboats for 85 years. From 1820 to 1880, it was a potent factor in the development of the trans-Mississippi territory, and for about 25 years, from 1845 to 1870, its importance in this respect can hardly be over-stated. It was the one great highway to all the western country. Were there to-day but a single railroad from the Mississippi River to the Rocky Mountains, its commercial value to the tributary country would be relatively no greater than that of the Missouri River during all this period. All operations in the far western country were planned with reference to it, and it was a controlling factor in the great movements which led to the subduing and final settlement of the West. The war with Mexico, the exodus of the Mormons, the vast migration to California, the later rush to Montana, the military subjugation of the Plains tribes, and the work of occupying and settling the vast Empire of the West, all relied to a great extent upon the aid of this mighty stream. Statistics have never been preserved showing the actual magnitude of this business, but it seems certain, from such information as is available, that it must have exceeded that of either the Ohio or Upper Mississippi, and probably of both combined.

As already stated, the greater part, in fact nearly all, of this extensive commerce was carried on without material assistance from the Government in improving the navigable channel. Except in the matter of limited expenditure in the removal of snags along the

Mr. Chittenden. lower course of the river, the Government did no channel work until the period of active boating had passed. As in the case of other tideless rivers of the United States, but to a more pronounced degree, the advent of the railroad proved the ruin of the river business. The difficulties of navigation on the Missouri have always been very great. The rapid current, the excessively shifting channel, and the prodigious accumulation of snags made boating at all times hazardous and uncertain. The number of steamboat wrecks in the history of the river is close to three hundred. High freight rates were necessary to insure against these dangers. The railroads cut these rates, and, by their greater convenience and certainty of operation, ruined the boat business. It was practically gone by 1880, about the time when the Government turned its attention seriously to the river.

It will naturally be asked why the tendency of events was not more clearly recognized at the time, and with it the inadvisability of spending great sums upon a work the utility of which was so much open to doubt. The answer is found in the extreme reluctance of the people along the valley to admit that the transportation route which had served their country longer than they could remember had at last ceased to be of value. They could not become reconciled to the fact that the steamboat must go. They longed for a revival of the business, and as it could not be under the conditions then existing, they asked for such an improvement of the channel as would enable the boats to compete with the railroads. They resolutely shut their eyes to the logic of events, and never fully realized the magnitude of the obstacles that stood in their way. They failed to appreciate the enormous physical difficulties of regulating the Missouri River so that it would maintain a navigable depth by scour. But, even more important, they failed to grasp the broader commercial features of the problem, *viz.*, that the river was a less convenient line for shippers; that it was wholly useless for passenger traffic where railroads were available; that it was entirely closed for several months of every winter; that over much of its course it did not flow in the right direction nor reach the most important centers of activity; and that, therefore, it could not adequately serve the ever increasing demands for transportation. All these considerations were ignored or overlooked, and it was decided to attempt to restore the river to its former high standing as a commercial highway. In the effort to realize this purpose, a vast expenditure of public money was made and a prodigious amount of work accomplished. The technical details are given by Mr. Fox in this paper. But the outcome was not what was desired. The waning commerce of the river continued to dwindle, without any reference to the heroic efforts being made to keep it alive, and, finally, the Government gave it up as a hopeless task.

Another reason which led to its abandonment more quickly than would otherwise have been the case was the general policy under which the work was conducted. To carry out the purpose of Congress a commission was created representing the interests of the valley. Adhering strictly to the theory of river and harbor improvement, *viz.*, that public expenditures on such works are authorized solely in aid of interstate commerce, the Commission logically undertook to carry on its work systematically and continuously from the mouth up stream, and always disapproved the diversion of any portion of its funds to individual localities not yet within the field of systematic work. This was the natural, logical method of attacking the physical problem. But it failed to grasp the practical aspects of a public work in which the people of the whole valley were interested. When the communities remote from the field of actual work came to understand that the systematic improvement might not reach their neighborhood for a generation to come, they became restive and dissatisfied, and succeeded in inducing Congress to divert so large a portion of the appropriations to special localities as to cripple effectually the Commission's scheme of continuous improvement. Mr. Chittenden.

A third condition that operated to the same end was the failure to recognize the urgent necessity for a certain class of work which might have been carried on advantageously with the channel improvement. This was the protection of the river banks from erosion. The Missouri River is undoubtedly the most destructive stream, in the matter of bank erosion, that exists on the globe. This is a sweeping statement, but the writer believes it to be correct. The evil is of a character which is extremely difficult to circumvent by individual effort because of the fact that the agencies at work are so powerful and reach so far that the individual land owner, unless a great railroad system, is absolutely at their mercy. It has always seemed to the writer that the Government, in its improvement work, could very properly co-operate with the land owners, and, wherever not incompatible with the maintenance of the navigable channel, could plan its work so as to protect the immensely rich and fertile bottom lands from the ravages of the river. The writer will presently give his reasons for thinking that the works best adapted to the maintenance of a good depth of water are those which would best serve the purpose of bank protection. With such a policy established, private parties would contribute materially to the protection of their property, and the expenditure of public money would yield a vastly increased benefit over what it would if confined exclusively to channel improvement.

In view of the recognized limitations upon river and harbor appropriations, the Commission, of course, was entirely consistent in

Mr. Chittenden. refusing to recognize bank protection as any part of its plan, except as it related exclusively to the improvement of the navigable channel. Local interests, on the other hand, felt that it was only by special allotments that they could derive any benefit from the appropriations made by Congress. The situation thus developed could not continue, for it was in direct opposition to the official plan of the work, and involved too great a departure from the theory of river and harbor legislation; for, while these special appropriations were made for the "improvement of the river" at the localities designated, this term was virtually a euphemism to cover up the real purpose in the protection of riparian property. As before stated, it has seemed unfortunate to the writer that the existing conditions could not have been recognized on their merits, and a system of improvement have been inaugurated, which, in co-operation with the efforts of land owners, would have been of inestimable value to the communities along the river. But since it could not be, or at least was not, so recognized, it was clearly the duty of Congress to withdraw from the river altogether, for the demands of navigation were not of themselves sufficient to justify any further large expenditure. The abandonment of the improvement practically took effect in 1902 when the Missouri River Commission was abolished, and it has fallen to the writer, in his official capacity, to superintend the obsequies of this once very considerable public work.

It should not be concluded that, because the policy of improving the Missouri has practically been abandoned, the expenditure of so much public money has been in vain. The paper of Mr. Fox indicates something of what it has bequeathed to the people of this valley and to those of the valleys of other similar streams. Probably few problems in river improvement have received the persistent, intelligent and painstaking study that this has. The characteristics of the stream were exhaustively studied. As the magnitude and cost of the problem began to develop, every effort was made to devise more economical and efficient methods of controlling the river; and it is doubtful if future experience will evolve anything of value, so far as the control of this river is concerned, that has not already been tried in these investigations. A large share of this work has been done by Mr. Fox himself, and the science of river engineering has been distinctly promoted by his efforts.

Among the valuable results of the Government work on the Missouri River may first be noted the surveys and maps of the valley. These cover the entire length of the stream from the Three Forks to the mouth. They are based upon a system of secondary triangulation and a line of precise levels. The surveys have been published in a set of eighty-five sheets with nine index sheets and two containing titles and explanatory data. The scale is one mile to the inch. There are also unpublished large-scale maps extending from the mouth to above Kansas City, and a great number of maps of special localities. Altogether, the data of this character available for public use are of great value. They are constantly called for, and are serving a most important purpose.

Mr. Chittenden.

The various types of works developed for controlling the river will find wide application upon all alluvial streams, and especially upon the Missouri itself; for the dwellers of the valley will always have with them the problem of self-preservation from the ravages of this stream, and they will find their greatest aid in the fund of information which the Government has provided for them through years of costly experimentation.

In criticism of the works themselves and the several types of construction made use of, the writer has drawn this conclusion, though somewhat at variance with the practice of the Commission: That those works which are built out boldly into the stream, at right angles, or nearly so, to its current, are less effective in improving the channel and in protecting property than those built approximately parallel to the current. The theory of the first class of works is, of course, that they contract the channel, force a larger flow through a smaller width, and thus compel the current to scour out a greater depth.

Two conditions of great moment operate against this system: First, there is the destructive energy of the river in flood with its enormous volume of water, its rapid current and its load of ice or drift. Ordinary dike construction, sooner or later, and generally sooner, yields to these agencies. The scour around the ends weakens their resisting power and causes them to succumb more rapidly. Bank-heads are less exposed to ice and drift, but are equally open to attack by scour. In the second place, this method of control seems to the writer to possess grave defects in principle. The natural effect of such non-yielding structures thrust bodily into a stream is to disturb and demoralize the flow. In an alluvial bottom, which yields almost to the touch of flowing water, these disturbances are likely to have far-reaching effects, throwing the river out of the alignment intended, and producing results quite different from those desired. Mr. Fox has referred to some of these defects on pages 62-64* of his paper.

In contrast with this method of improvement by force, is that of longitudinal works, such as bank revetment or dikes parallel with the current. These avoid the drawbacks mentioned above. The ice and drift rarely lodge heavily upon them. They do not disturb the flow of the river, but by their smooth and even alignment seem actually to attract the flow in their direction and to maintain in

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* *Proceedings*, Am. Soc. C. E., for January, 1905.

Mr. Chittenden. that way an increased depth and uniformity of section. They accomplish their purpose of improving the channel by coaxing rather than by driving.

From the nature of the two classes of work, revetment is more permanent than dike work. The latter being largely of wood, partly beneath the water and partly above, must inevitably fall by natural decay in a comparatively short time. Revetment work has no perishable material above water, and, therefore, is largely exempt from the processes of decay. Dike work is exposed to the direct onslaught of the river, with its ice and drift and rapid current. The revetment rarely, if ever, receives the attack directly, but at such an oblique angle that it glances off with comparatively little impression. Dike works are avowedly for the purpose of changing the flow of the river; their influence is far reaching; and the current may be thrown against other banks, causing new destruction and giving rise to just complaint. The revetment never has this effect, but, on the other hand, tends to hold the river in its existing channel.

An exception to the above criticism upon spur-dikes is found in the case of short dikes of, say, 100 ft. in length, placed comparatively close together and built on a steep grade from the top of the bank to about low water at the outer end. These dikes serve admirably the purpose of bank protection, are but little exposed to ice and drift, and, by their closeness to each other, do not disturb the flow of the river as much as do the long, high dikes spaced at greater intervals. Their cost, moreover, is only about half that of standard revetment.

Mr. Le Conte. L. J. Le Conte, M. Am. Soc. C. E. (by letter).—The writer is greatly impressed by this very instructive paper. He is especially interested to learn the striking likeness that the Lower Missouri River bears to the abnormal physical features of the Feather River and Lower Sacramento River, in California.

In 1876 the writer was engaged in building temporary wing-dams on the Feather River, between Marysville and the mouth, with the view of ameliorating navigation for the season as much as possible. The physical conditions of the stream, overloaded with mining débris, certainly beggars all description. The experience gained while working on this river was so remarkable and novel that he observed conditions carefully and took full notes of all the physical features peculiar to that river. It did not take the writer very long to arrive at the conclusion that the great over-mastering physical feature which dominated everything connected with the improvement of the channel way was undoubtedly the progressive bed-flow of sand. This feature wiped out, so to speak, the ordinary hydraulic characteristics entirely, and introduced an altogether new controlling element which was extremely difficult to deal with, chiefly on account of the utter lack of knowledge regarding it. Mr. Le Conte.

Generally speaking, it may be said that in the bends the water surface was not more than 90 or 100 ft. wide and from 6 to 10 ft. deep, and the flow was quiet and smooth. On the crossings, however, the flow was fully 600 ft. wide with a uniform depth of only from 12 to 14 in. Such a river section as this is truly phenomenal. The entire surface was so-called "spotted water," giving indisputable evidence of a general bed-flow for the entire width of 600 ft. In wading over this crossing, in rubber boots, one has to keep moving all the time, as standing in one place too long would probably lead to his gradually sinking down out of sight. The sandy bottom was all alive and moving down stream. The temporary wing-dams were generally built on these crossings to concentrate the water flow, and 24 hours after construction a dry sand bar 1 000 ft. long by 400 ft. wide would form below the dam, the fill above the dam being much less in size. These dams were at first built 6 ft. in height throughout their entire length, but they gradually settled down into the moving sand until at the outer end they practically reached the water surface, at the same time, the entire dam was swinging down stream radially some 20° from the alignment first built upon, and then the dam apparently settled down and came to a stand. This would seem to indicate, roughly, that only the upper 6 ft. of the bed-flow was moving at low stages of the river.

Unfortunately, circumstances prevented the writer from observing the Feather River during flood stages, but he did manage to observe the flood stages on the Lower Sacramento River near the head of Steamboat Slough. The facts observed there are very interesting and highly instructive. When the river was bank full, and flowing with a surface velocity of 7 ft. per sec., soundings were taken across the channel, and the results when plotted showed that the sandy bottom had come up just about as much as the water had raised on the gauge; in other words, the high-water sectional area was only a very little more than the low-water sectional area. But the real difficulty was in obtaining good reliable soundings during high-water stage, the sandy bottom feeling like a pot of boiling mush, so that in any cast of the lead one could not tell within 3 ft. of what the sounding ought to be; indeed, the writer has really very serious doubts as to whether the high-water sectional area, in point of fact, was any greater than the low-water sectional area. This condition continued during the entire time of his observation, and, therefore, was not a mere transition stage of the river, or due to the passage of a sand wave. In such rivers as these, of course, the usual method of gauging the river discharge, by the gauge height readings, is out of the question entirely. He was much pleased to note

Mr. Le Conte. the magnificent results obtained by the Missouri River Commission at the forty-five mile stretch near Jefferson City. This work is a masterpiece of good river engineering, and will always stand as a monument to the ability and skill of the Engineer Officers in charge.

The excellent details supplied by the author are full of interest to the river engineer, who instinctively depends upon actual experience as the best guide and most reliable teacher. In fact, it may be said that his practice is all based on experience gained by hard work and costly experiments. What is good for one river may or may not be suitable for another; so much depends upon local conditions and the materials that are available and handy. The remarkable feature brought out clearly by the author, namely, the universally divided flow in the improved channel, is a most troublesome fact which adds another item to the long list of difficulties to be encountered. When a broad, general and persistent fact like this is met there is always a simple cause for it. Although the writer is not prepared to speak positively, yet, judging from his past experience, he is inclined to think that this feature is a natural phenomonen of bed-flow, and that the mid-channel shoal is the characteristic feature of this bed-flow.

It is humiliating to note how little the public appreciates the true intrinsic value of improvements to river navigation. The river, after all, is the only true friend and freight controller the public has. The public should never be so blind to their own interests as to overlook systematic river improvements.

Moreover, the wealth added to the adjoining country, entirely incidental to the improvement of navigation, is a matter which should not be overlooked. The writer is credibly informed that in a distance of 18 miles, near Jefferson City, new land formed by improvements equals 5 500 acres, and the area of land protected by the same improvements equals 12 800 acres. This would fairly represent the sum of $915 000, or more than $50 000 per mile of river. This amount, in itself, would practically pay for the improvements.

Vol. XXXI. APRIL, 1905. No. 4.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PAPERS AND DISCUSSIONS.

This Society is not responsible, as a body, for the facts and opinions advanced in any of its publications.

MAXIMUM RATES OF RAINFALL AT BOSTON.

Discussion.*

By S. Whinery, M. Am. Soc. C. E.

Mr. Whinery.

S. Whinery, M. Am. Soc. C. E. (by letter).—The importance of adopting and using appropriate and convenient units, in dealing with scientific and engineering data and computations, is universally admitted. As a measure of the intensity of rainfall, the unit which has been generally used by engineers is the rate of precipitation in inches per hour. This is, in some respects, an awkward and inconvenient unit, and the writer suggests that for it be substituted the actual depth, in inches, falling in the stated time. The measurement and designation of the quantity of rainfall, in inches of depth over the surface, is unobjectionable, and has become so well established that no change is desirable. But to designate the rate of precipitation, it would seem to be simpler and more satisfactory to refer it to the depth, in inches, falling in a given period of time. Thus, it is now the common way to say that for a period of 5 minutes rain fell at the rate of 3.6 in. per hour: It would be more direct and simple to say that for the period of 5 minutes the rainfall was 0.3 in. This is a direct expression, and the quantity is readily convertible into the common units of quantity of water, as, for instance, cubic feet per acre. This method of expressing rate of rainfall is the more desirable since the Government Weather Bureau reports of excessive precipitation are published in substantially this form,

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* Continued from March, 1905, *Proceedings*. See December, 1904, *Proceedings* for paper on this subject by Charles W. Sherman, M. Am. Soc. C. E.

Mr. Whinery. and we are largely dependent upon these reports for extended data on the subject, since the Bureau now maintains automatic recording rain-gauges at a large number of stations.

Diagrams of maximum rainfall constructed from records kept in this way show directly the quantity of water, in inches of depth, that may be expected to fall in any given time. Thus the author's curve, the equation for which is given as $i = \frac{38.64}{t^{0.687}}$ (Plate LI*), transformed as here suggested, would appear as shown in Fig. 3, and the equation of the curve would become $d = \frac{38.64}{t^{0.687}} \times \frac{t}{60}$, where d = the total precipitation, in inches, falling in t minutes.

(This formula and the author's curve are erroneous for the shorter periods of time. There are no observations, so far as the writer knows, indicating a rainfall at Boston at the rate of 12.3 in. per hour for 5 minutes. The author's equation gives a rate of precipitation for 1 minute of 38.64 in. per hour, and as the time decreases the rate approaches infinity.)

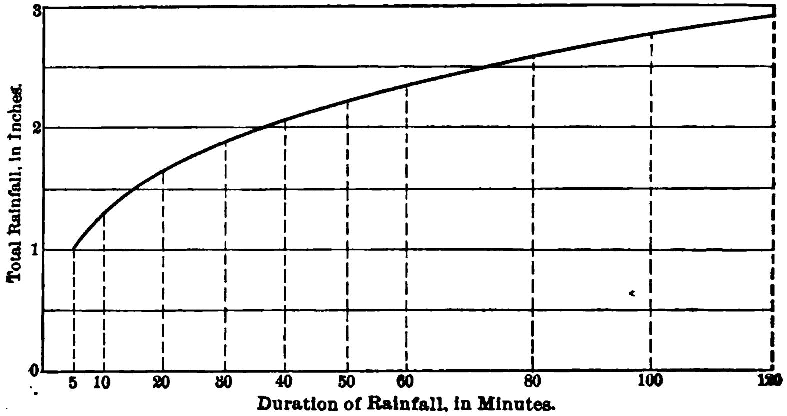

FIG. 8.

Discussion of the possibility of constructing any formula or diagrammatic curve which will represent with approximate correctness the rate of rainfall at various places for various periods of time is probably more interesting in the abstract than useful practically, and it will become less useful as records of maximum rainfall become available for stations not very far apart, covering the whole country. But, in the absence of such full data, a formula which might be depended upon for reasonably correct results would undoubtedly be of value. Mr. Whinery.

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* *Proceedings*, Am. Soc. C. E., for December, 1904.

Perhaps, therefore, the writer may be excused for adding another attempt to devise such a formula. He has been under the impression heretofore that some rude relation probably existed between the rate of precipitation at any station and the normal annual rainfall at that station, but an examination of the records does not confirm that hyothesis. Thus, the curve for excessive precipitation, plotted from available records, for New Orleans, where the normal annual rainfall is 60.3 in., corresponds very closely with that for St. Paul, where the normal annual rainfall is 28.8 in.

It was for the purpose of testing this hypothesis that the records of excessive rainfall at nine cities widely distributed, geographically, over the eastern part of the United States, and having quite a wide range in annual rainfall, were collected and examined. These cities were:

	Normal Annual Rainfall.		Normal Annual Rainfall.		Normal Annual Rainfall.
Boston	45.4 in.	Atlanta	50.4 in.	Cincinnati	42.1 in.
Washington	42.9 "	New Orleans	60.3 "	Chicago	34.0 "
Savannah	50.4 "	St. Louis	40.8 "	St. Paul	28.8 "

The records of excessive precipitation at these stations, for various periods of time up to 2 hours, were collected and tabulated (largely from the publications of the Government Weather Bureau, but supplemented by such other records as were available). A few (usually three or four) of the heaviest rainfalls at each station for the various periods of time were then diagrammed, and a curve constructed. These curves embraced all the recorded rainfalls for the various periods except a few very phenomenal downpours at some of the stations, not deemed likely to recur for long periods of time. In no case do the records of more than one rainstorm at any station lie without the curve, and then, usually, for but a few of the time-periods. The ordinates to the curve for each station were then tabulated, and the arithmetical mean for each period of time computed, and these means used as ordinates for plotting a mean curve. The original curves were found not to differ from each other very widely, when the apparently lawless character of rainstorms is considered. Table 4 shows, for each period of time, the maximum and minimum length of ordinate to any of the nine curves for the various periods of time, and their mean.

The curve shown by the broken line in Fig. 9 is platted with the mean ordinates from Table 4. This curve is somewhat irregular, Mr. Whinery. and no equation exactly representing it was found. But a curve, the equation for which is

$$d = \frac{0.6\,t}{(t+4)^{\frac{2}{3}}},$$

in which d = the rainfall, in inches, for any number of minutes, t (up to 120 minutes) coincides with it sufficiently close for practical purposes. This curve is shown by the full line in Fig. 9.

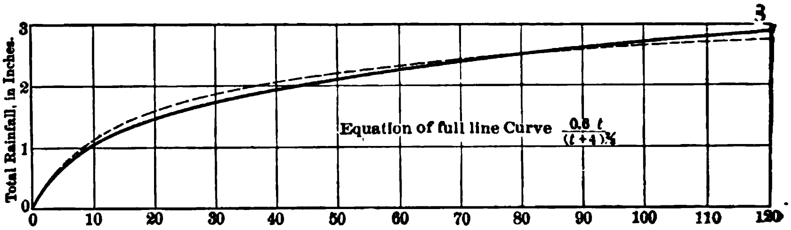

FIG. 9.

The equation is sufficiently simple to make its use reasonably convenient as a formula for excessive rainfall. It is recognized that neither the number of stations involved nor the time covered by the records warrants confident dependence upon its accuracy or reliability, but it is submitted as possibly more reliable than those heretofore proposed, and as giving results which may be safely used where satisfactory data based upon actual observations are not available.

TABLE 4.—MAXIMUM, MINIMUM AND MEAN OF ORDINATES TO EXCESSIVE RAINFALL CURVES IN NINE CITIES OF THE UNITED STATES.

Time, in minutes.	Maximum ordinate.	Minimum ordinate.	Mean of nine ordinates.
5	0.90	0.62	0.71
10	1.30	0.88	1.09
15	1.65	1.16	1.40
20	1.85	1.32	1.59
25	1.95	1.45	1.73
30	2.05	1.55	1.82
35	2.04	1.63	1.93
40	2.20	1.68	2.06
45	2.33	1.75	2.14
50	2.44	1.80	2.20
60	2.60	1.90	2.32
80	2.78	2.03	2.50
100	2.90	2.16	2.63
120	3.00	2.24	2.74

As intimated heretofore, results given by it would not include some of the phenomenal rainfalls in some of the cities, but if the

Mr. Whinery.

coefficient of t in the numerator were increased from 0.6 to 0.7, nearly all these phenomenal storms would be covered, and the formula thus modified could be safely used, if it were thought wise by the engineer to provide against such phenomenal downpours.

The available records do not seem to be sufficient to warrant an attempt to apply the formula to periods of time beyond 2 hours. In fact, there seems to be good reason to believe that after that time the curve should deflect downward; in other words, anomalous as it may seem, the total precipitation in storms lasting, say, 4 hours, appears to be less than often occurs in storms of 2 hours' duration or less.

MEMOIRS OF DECEASED MEMBERS.

NOTE.—Memoirs will be reproduced in the Volumes of *Transactions*. Any information which will amplify the records as here printed, or correct any errors, should be forwarded to the Secretary prior to the final publication.

JACOB ALBERT LATCHA, M. Am. Soc. C. E.

DIED NOVEMBER 30TH, 1904.

The record of the life of J. Albert Latcha, which closed at the City of Coldwater, Michigan, on November 30th, 1904, is one worthy of note. Born in the State of Pennsylvania, of a Huguenot family which had settled in the United States at an early date and held letters patent, for land from the Government, dated in 1784, it was in his youth that he chose the profession in which afterward he rose to eminence.

Having gained a solid education at the West Branch Academy, he supplemented it by a special course in mathematics and engineering under Professor Parker, of the Naval Academy, at Annapolis. This in turn was followed for years, and in fact throughout his entire active life, by a well-selected and systematic course of reading, and by constant study. Those who were admitted to the privilege of his friendship in later years often were surprised by his mental grasp, his wide information, and his ready apprehension of every subject presented.

Beginning his railway experience in 1865, as Assistant Engineer with the Philadelphia and Reading Railroad Company, in the next year Mr. Latcha was appointed to a similar position on the First Division of the Union Pacific Railroad, in making the original surveys across the continent from Kansas City to San Francisco, *via* the 32d and 35th parallels. On this survey, subsequently, were built both the Southern Pacific Railway and the Atchison Railroad. Mr. Latcha continued in charge to the Coast, and returning in 1868, he entered the service of the Pennsylvania Railroad, continuing therein for about nine years, and building most of the important lines west of Pittsburg.

In 1880, Mr. Latcha began the construction of the New York, Chicago and St. Louis Railway, built in the interests of the Seney Syndicate. The preliminary surveys for this railway were begun in February, 1881, and the road from Buffalo to Chicago, 510 miles, was completed and ready for through passenger trains by the middle of August, 1882; being 480 working days, or 18 months.

In November, 1886, Mr. Latcha was appointed Engineer and

Superintendent of Construction of the Duluth, South Shore and Atlantic Railway. Preliminary surveys were begun on November 5th; the line was located from the Marquette Iron and Copper Range to Superior in 90 days; contractors began work in February, 1887, and 225 miles of railroad were built and track laid through unbroken forests in 13 months.

At different periods, during the years mentioned above, Mr. Latcha also held the presidency of the Toledo, Tiffin and Eastern Railroad, the Toledo and State Line Railroad, the Union Bridge Company, the Toledo and Milwaukee Railway, the Michigan and Ohio Railroad, and the Toledo, Marshall and Northern Railroad; besides being Chief Engineer and Superintendent of Construction of several of the same companies. Still other railroads, construction works, and companies might be mentioned in which Mr. Latcha was actively interested.

In all his wide and varied experiences, Mr. Latcha was noted for his singularly close and accurate estimates of the cost of construction work of all kinds. This was observed by those at the head of the departments of finance, as well as by those who worked under his direction. His executive ability was marked, and his mental endowments fitted him from early life to be a leader of men.

Regarding his professional work, Mr. George B. Roberts, late President of the Pennsylvania Railroad, once stated before the Board of Directors in the office of the company, at Philadelphia, that Mr. Latcha had done more work in less time and at less cost than any other engineer who had ever reported to him. Mr. John P. Green, Second Vice-President of the Pennsylvania Railroad, in a personal letter, declared Mr. Latcha to be one of the best equipped men of his profession the company ever had in its service.

Mr. Latcha was elected a Member of the American Society of Civil Engineers on May 7th, 1873, and at the time of his death he was not far behind those longest in such continuous membership.

For several years prior to the burning of the Hotel Windsor, Mr. Latcha and his wife lived at that New York hotel, the city indeed long having been considered their place of residence; and both before and during that time they made trips to Europe, the Pacific Coast, and to other parts of this country.

At various times, especially during his residence in New York, Mr. Latcha was an occasional contributor to the *North American Review* and *The Forum*. He was a firm believer in railroads, as against canals, as affording the best possible means for the transportation of grain and other western products to the Atlantic Coast. In several well-considered articles he forcefully advocated the construction of one or more Government freight lines for this purpose, and showed how the result could be brought about within reasonable limits, and the leadership of the United States in supplying the grain markets of the world thus be secured and maintained. Recent movements in Congress, or by Congressmen, indicate that his ideas ultimately may be carried out.

Not long before the conflagration that destroyed the Hotel Windsor, Mr. Latcha purchased and handsomely remodeled the parental home of Mrs. Latcha, at Coldwater, Michigan, upon the death of her father and mother, intending to use it chiefly as a summer residence. Within a short time after taking possession of the new home, Mr. Latcha suffered a sudden attack, somewhat paralytic in nature, from which, thereafter, he only partially recovered.

Although remaining an invalid for several years, Mr. Latcha never lost his interest in the affairs of the world, and as lately as the week previous to his death he had been consulted upon great enterprises already started and others just developing. When the offer of Mr. Carnegie came up before the Society, Mr. Latcha, with his usual discernment, committed himself to the side which finally won, and no engineer felt more gratification than he over the result.

Throughout his long and, to a man of his strong and self-reliant nature, particularly trying illness, Mr. Latcha displayed a spirit of marked patience and great self-control. The end had long been foreseen by him. Those who were closely allied with Mr. Latcha during the days of his professional activity declare that they have lost a dear and true friend.

At the funeral service, held at Coldwater, on Sunday afternoon, December 4th, 1904, the Rev. H. P. Collin, pastor of the First Presbyterian Church, and a long-time friend of the family, said of Mr. Latcha:

> "The memory of his refined, rich, noble nature must ever abide in the minds of those who knew him in the fellowship of home and friends. The longer and more active part of Mr. Latcha's life was not lived in our community. He was prominent in large and important public interests in the industrial world of our country. His mental grasp of railway possibilities was broad, far-reaching, and reliable in an unusual degree. He was patriotic in his spirit, and many of his fellow citizens besides us who are gathered here to-day gratefully recognize the value of his contributions to our nation's life."

In his married life Mr. Latcha was particularly happy. His wife was a daughter of the late Bleecker Lansing Webb, a pioneer dry-goods merchant and business man of Coldwater, Mich., who himself was a native of New York City.

WILLIAM BESWICK MYERS-BESWICK, M. Am. Soc. C. E.*

DIED DECEMBER 27TH, 1904.

William Beswick Myers-Beswick was born at Leeds, England, on July 2d, 1850. He was the son of the late Mr. W. H. N. Myers, of Leeds, and took the surname of Beswick on inheriting the ancient manorial property of Gristhorpe, near Filey, in Yorkshire.

He served his articles with Messrs. Filliter and Rofe, Hydraulic Engineers, of Leeds, and afterward went through the civil engineering course at Berlin University. On his return to England he joined the staff of the late Mr. John Fraser, of Leeds. He continued that gentleman's practice, in conjunction with his brother-in-law, Mr. H. J. Fraser, and after the death of the latter continued in practice by himself, with offices in Westminster and Leeds, and, for the four last years, in partnership with Mr. W. P. Morison and Mr. G. F. Murray, both of whom had co-operated with him as assistants for many years.

His practice comprised the construction of many important branches of the Great Northern Railway, in Yorkshire and Leicestershire and works for the North Eastern and London and North Western Companies, including some heavy tunneling, viaducts, and a great variety of bridge work. On the Pudsey Branch he constructed the Tyersall Bank, the extreme height of which is 110 ft., and which contains about 600 000 cu. yd. of material. He also conducted an extensive parliamentary and general consulting practice.

Mr. Myers-Beswick was a Member of the Institution of Civil Engineers, a Member of the Institution of Mechanical Engineers, and a Fellow of the Geographical Society. He was elected a Member of the American Society of Civil Engineers on January 3d, 1894.

Mr. Myers-Beswick died at Malvern on December 27th, 1904.

ALONZO J. TULLOCK, M. Am. Soc. C. E.†

DIED JULY 21ST, 1904.

Alonzo J. Tullock, the subject of this sketch, died at his home in Leavenworth, Kansas, on July 21st, 1904, at the age of 50 years. He was born on a farm near Rockford, Illinois, in 1854, of Scotch parentage, his father, George Tullock, having come to this country from Edinburgh, Scotland, in the early Forties. His school education was commenced in the country schools near his birthplace, continued in the high school at Rockford, Illinois, in the University of Illinois at Champaign, and finally completed at the University of Michigan, where he received the degree of Civil Engineer in 1876.

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* Memoir prepared by W. P. Morison, Esq.

† Memoir prepared by Alfred Noble, A. A. Robinson and E. H. Connor, Members, Am. Soc. C. E.

In 1878 he was married to Miss Kitty B. Southwick, of Rockford, Illinois. The union was most happy, and was blessed by the birth of three children, a daughter, Florence L., a son, Hubert S., and a daughter, Lucy M. Tullock. Miss Florence L. Tullock has recently been graduated from Smith College, at Northampton, Massachusetts, and the younger daughter, Lucy M. Tullock, is now attending the public schools in Leavenworth. The son, Hubert S. Tullock, at the time of this writing, is a junior in the engineering department of the University of Michigan, his father's Alma Mater.

Soon after his graduation, Mr. Tullock entered the employment of Fox and Howard, a firm of contractors in Chicago, but in 1879 he entered the bridge building firm of Insley, Shire and Tullock, at Leavenworth, Kansas, and from that time until his death he devoted his time principally to bridge, viaduct and wharf construction. At the time of his death he was, and had been for twenty years, the proprietor of the Missouri Valley Bridge and Iron Works, successor to the original firm.

Mr. Tullock built many important bridges in the territory west of the meridian of Chicago, besides building during the early days, between 1880 and 1890, many Howe trusses and combination wood and iron bridges, styles so much in vogue during that period. In the territory mentioned, Mr. Tullock probably built more bridges than any other company or firm. Among the most important structures built by him were: the substructure of a railway bridge across the Missouri River at Leavenworth, Kansas, completed in 1894; a highway bridge across the Missouri River at Jefferson City, Missouri, completed in 1896; a railway bridge across the Red River on the line of the Kansas City Southern (Port Arthur Route); railway bridges across the Arkansas, Canadian and other large rivers, for the St. Louis Southwestern Railway (Cotton Belt Route), Texas and Pacific Railway, and other roads at various points. He built the very difficult pneumatic foundations for the Texas and Pacific Railway's bridge across the Atchafalaya, one of the outlets of the Mississippi River into the Gulf of Mexico. Various other pneumatic and deep foundations for bridges across western rivers, which are most difficult to deal with owing to their very steep water-sheds and their extreme freshets, were built by him. His last important work was the construction of the bridges on the St. Louis, Kansas

City and Colorado Railway (Rock Island System), among which was one very high structure over the Osage River. This bridge contained one span 375 ft. in length and one concrete pier with a total height of 109 ft., resting upon a pneumatic foundation. This is probably the highest concrete pier yet constructed.

In 1900, Mr. Tullock, in conference with Alfred Noble, Past-President, Am. Soc. C. E., designed the important wharf built by the Mexican Central Railway, for the Mexican Government, at Tampico. Mr. Tullock was made engineer of this important work, and took complete charge of the same during construction. This wharf was built on 454 piers, a large number of which were on pneumatic foundations, reaching the depth of about 50 ft. below mean tide. A full description of this important work has recently appeared in the technical press.

During a busy and studious life, Mr. Tullock accumulated a large and valuable library in which are many rare books, and especially many volumes relating to the Louisiana Purchase, within which territory was located the city chosen for his home.

Mr. Tullock, by his simplicity and force of character and his excellent judgment, attracted to himself men of character and learning. By his uniform courtesy and fair dealing, he commanded the confidence and esteem of those with whom he was associated, and as a friend, he could be depended upon in any emergency.

Mr. Tullock was elected a Member of the American Society of Civil Engineers on June 6th, 1883.

MACY STANTON POPE, Assoc. M. Am. Soc. C. E.*

DIED DECEMBER 10TH, 1904.

Macy Stanton Pope was born in East Machias, Washington County, Maine, on July 26th, 1869, of sturdy New England parentage, his father, James Otis Pope, and his mother, Olive Chase, both being natives of East Machias.

His early training was obtained in the public schools of East Machias, and in Washington Academy, located in his native town, from which he was graduated in 1888.

Brought up in a community chiefly interested in lumber and shipping, he spent much of his time in his father's mill, and in the woods, of which his father owned large tracts. He thus acquired, not only an intimate knowledge of these industries and a deep interest in them, but habits of close observation and independent thought, which marked his later life and work.

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*Memoir prepared by Leonard Metcalf, M. Am. Soc. C. E.

In the fall of 1888 he entered the Massachusetts Institute of Technology, and was graduated from the Department of Civil Engineering in 1892.

He then entered the employ of the Associated Factory Mutual Fire Insurance Companies, of Boston, taking part in a series of tests upon cast-iron water pipe and fittings being conducted at Nashua, New Hampshire, by John R. Freeman, M. Am. Soc. C. E.

In the following fall he was called to the Massachusetts Institute of Technology as Assistant to Professor Dwight Porter in the Department of Hydraulics, but resigned his position at the end of the academic year to take up practical work again, and to re-enter the employ of the Factory Mutuals Company.

Here his time was divided between the testing department, in which he made tests of various fire protection and prevention devices; the inspection department, in which he visited mills in different parts of the country, and made plans of and reported upon them; and in the private work of Mr. John R. Freeman, then engaged, in addition to his regular duties as Engineer to the Factory Mutuals Company, in preparing plans for the improvement of the Pennichuck Water-Works at Nashua, New Hampshire, and of the power plant of the Piscataquis Pulp and Paper Company, and in various other kindred projects.

In February, 1898, Mr. Pope obtained leave of absence from his company to devote himself to the lumber interests of his family estate. Later, after making a somewhat extended tour, through the southern and western States, with his mother, he resumed his active connection with the company, in June, 1900.

From this time his work lay principally in the inspection department of the company; first, in routine inspection work, later, in special inspections. His early training and natural traits, combined with his personal experience with the practical affairs of business, stood him in good stead and made him a most valuable man for the department. Clear headed, well balanced, and judicially minded, he was well fitted to do the work which fell to him, and merited the words of commendation of one of his associates, who wrote, after Mr. Pope's death:

> "It is the verdict of all that the work done in each of these various fields was well done, and that the results were received by those who used them with the fullest confidence. In every case strong common sense and a clear appreciation of relative values were predominating characteristics."

Mr. Pope was much interested in engineering matters, and was a member of various engineering societies, among them The American Society of Civil Engineers, in which he was elected an Associate Member on May 2d, 1900, The Boston Society of Civil Engineers, The New England Water Works Association, The Society of Arts, and of the Technology and Appalachian Mountain Clubs.

He was devoted to his old home and took a warm and active interest in its affairs, as was shown by his presenting to the town of East Machias, jointly with his brothers, John A. and Warren F. Pope, a new bridge across the East Machias River. This structure, a fine three-span, reinforced concrete masonry arch, was built to replace a dangerous old timber crib bridge, not only as a memorial to the Pope family, which had been prominently identified with the affairs of the town for a century, but as an object lesson to the community.

His Alma Mater and the Washington Academy, of which he was a trustee, also claimed Mr. Pope's interest, and were substantially remembered by bequests in his will.

Last summer Mr. Pope took the opportunity to travel abroad for some months for rest and recreation, but, shortly after his return, serious symptoms developed, and he died of acute Bright's disease at Brookline, Massachusetts, on December 10th, 1904.

Quiet and reserved to the world, but a warm and loyal friend, simple in tastes, with high ideals, a well balanced and indomitable worker, Macy Stanton Pope will long be remembered by his friends as a good example of a fine and virile type of New Englander.

FREDERICK REGINALD FRENCH, M. Am. Soc. C. E.*

DIED NOVEMBER 20TH, 1904.

Frederick Reginald French, son of Horace and Mary E. Gilleter French, was born in West Lebanon, New Hampshire, on September 25th, 1873. He attended the public schools of West Lebanon and White River Junction, Vermont, and entered the Scientific Department of Dartmouth College in 1889. After two years in college, he was employed on the Concord and Montreal Railway, in northern New Hampshire, and for two years was with the Niagara Falls Paper Company, as assistant on mill construction, and during the last year had responsible charge of the surveying and drawing for the tail-race tunnel connecting the wheel-pit of the Paper Company and the tunnel of the Niagara Falls Power Company.

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*Memoir prepared by Arthur W. French, M. Am. Soc. C. E.

An incident connected with his early work is noteworthy, as an indication of the ability of the young man. The problem of making detailed drawings and patterns for the cut-stone work, at the intersection of the circular paper mill tunnel with the horse-shoe shaped main tunnel, gave the engineers connected with the work much study and discussion. Mr. French, becoming interested, suggested that he could work out a solution. Believing that the young man had little idea of the difficulty of the problem, he was told to take his time and try it. He produced his drawings, and, after careful examination by his superior, they were accepted and he was sent to the quarry to instruct the stone-cutters in preparing the work. Erection proved the problem to have been correctly solved. For a boy with but two years' college training, and no previous experience in stone-cutting work, this was considered quite remarkable.

Mr. French continued in mill construction, having engineering charge for the Shattuck and Babcock Company, in Wisconsin, until the fall of 1894, when he returned to his studies in the Thayer School of Civil Engineering at Dartmouth.

During the two years in the school, he was employed during all vacations, first with Wise and Watson, of Passaic, New Jersey, on construction at the Dundee Chemical Works, and later, under Professor Robert Fletcher, Consulting Engineer, as Engineer on bridge foundations at White River Junction, Vermont.

Upon graduation from the engineering school, in 1896, he became Chief Engineer for the Niagara Falls Paper Company, and had supervision of plans for, and construction of, extensive buildings and special machinery.

From the latter part of 1898 to 1900, he was engaged in waterworks construction in White River Junction, mill construction at Wilder, Vermont, and as joint proprietor of a machine shop and foundry business at Niagara Falls, New York.

Compelled by poor health to seek a milder climate, he traveled through Mexico in 1900, and there became associated with Edgar K. Smoot, M. Am. Soc. C. E., on the harbor improvements at Manzanillo. He remained with Mr. Smoot up to the time of his death, serving first as Assistant Engineer, later as Engineer in charge of construction at Manzanillo, and finally as Consulting Engineer, with headquarters in San Francisco.

He designed much of the special machinery for placing the great stone blocks used in the construction of the breakwater, including a steel derrick of simple and economical design, with a capacity of 50 tons, and special cars for the transportation of the stone.

As an engineer, he was possessed of great industry and perseverance, and had a genius for machine design. A keen imagination, which was ever active, was backed by great good sense and a sure knowledge of mechanical principles. It was his fortune to be connected with large enterprises, and his delight was in the solving of difficult problems. Still, he was ever faithful in the smallest details.

A number of useful inventions were made by Mr. French, several machines connected with paper mill work and an "area cableway," for conveying materials to all points within rectangular areas, being the most important.

His quiet and modest manner, together with the sterling qualities of his character, made firm friends for him among all with whom he came in contact.

His unselfish devotion to duty and his courageous fight against disease during the last years have taught his intimate friends to consider him a hero.

Mr. French was married to Martha O. Hathaway, on February 24th, 1898, and he is survived by his wife and one daughter. He was elected a member of the American Society of Civil Engineers on September 7th, 1904.

PROCEEDINGS

OF THE

AMERICAN SOCIETY

OF

CIVIL ENGINEERS.

(INSTITUTED 1852.)

VOL. XXXI. No. 5.
MAY, 1905.

Edited by the Secretary, under the direction of the Committee on Publications.

Reprints from this publication, which is copyrighted, may be made on condition that the full title of Paper, name of Author, page reference, and date of presentation to the Society, are given.

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NEW YORK 1905.

Entered according to Act of Congress, by the AMERICAN SOCIETY OF CIVIL ENGINEERS in the office of the Librarian of Congress, at Washington.

American Society of Civil Engineers.

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Term expires January, 1906:	*Term expires January, 1907:*
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S. L. F. DEYO.	E. KUICHLING.

Secretary, CHARLES WARREN HUNT.

Treasurer, JOSEPH M. KNAP.

Directors.

Term expires January, 1906:	*Term expires January, 1907:*	*Term expires January, 1908:*
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JOSEPH O. OSGOOD,	NELSON P. LEWIS,	MORRIS R. SHERRERD,
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M. L. HOLMAN,	MORRIS R. SHERRERD,	HEZEKIAH BISSELL,
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◆

The House of the Society is open from 9 A.M. to 10 P.M. every day, except Sundays, Fourth of July, Thanksgiving Day and Christmas Day.

HOUSE OF THE SOCIETY—220 WEST FIFTY-SEVENTH STREET, NEW YORK.

TELEPHONE NUMBER. - - 583 Columbus.
CABLE ADDRESS, - - - - "Ceas, New York."

Vol. XXXI. MAY, 1905. No. 5.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PROCEEDINGS.

This Society is not responsible, as a body, for the facts and opinions advanced in any of its publications.

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MINUTES OF MEETINGS.

OF THE SOCIETY.

May 3d, 1905.—The meeting was called to order at 8.40 P. M.; Vice-President E. Kuichling in the chair; Chas. Warren Hunt, Secretary, and present, also, 131 members and 22 guests.

The minutes of the meetings of April 5th and 19th, 1905, were approved as printed in the *Proceedings* for April, 1905.

A paper by R. D. Coombs, Assoc. M. Am. Soc. C. E., entitled "Round-House Framing" was presented by the Secretary. A second paper, entitled "A Few Remarks on Foundations," by L. L. Buck, M. Am. Soc. C. E., was presented by the Secretary, and discussed by Messrs. C. H. Fuller, R. P. Miller, J. P. Whiskeman, C. A. Ruggles, H. F. Dunham and H. C. Lowrie.

Ballots for membership were canvassed, and the following candidates elected:

As Members.

George Berry, Brooklyn, N. Y.
Louis Livingston Brown, New York City.

José Antonio Canals, San Juan, Porto Rico.
Edward Ike Cantine, East Orange, N. J.
Frederick James Easterbrook, New Haven, Conn.
Hector James Hughes, Cambridge, Mass.
James Alexander Jamieson, Montreal, Que., Canada.
Henry Japp, Long Island City, N. Y.
James Barney Marsh, Des Moines, Iowa.
Lardner Vanuxem Morris, Brooklyn, N. Y.
William Nelson Page, Ansted, W. Va.
Frederic Auten Combs Perrine, New York City.
Alfred Edward Phillips, Chicago, Ill.
William Haselton Puffer, Guanajuato, Mexico.
Charles Augustus Van Keuren, Jersey City, N. J.
John Van Vleck, New York City.

As Associate Members.

Carl Lincoln Bannister, Rome, N. Y.
Carroll Blake, Brooklyn, N. Y.
John Potter Congdon, Pocatello. Idaho.
Keith Osmond Guthrie, Brooklyn, N. Y.
Charles Edward Howe, Wabash, Ind.
Harold Walton Hudson, Harrisburg, Pa.
Edward Clinton Jansen, Shanghai, China.
Boudinot Gage Leake, Fort Worth, Tex.
Walter Raleigh Lewis, Jr., Littleton, Colo.
Carlos Lobo, Brooklyn, N. Y.
Elbert Emerson Lochridge, Springfield, Mass.
Ernest Manchester, Melbourne, Australia.
Arthur Edmund Owen, Jersey City, N. J.
Herbert Lincoln Rogers, New York City.
Fred Winton Sarr, Syracuse, N. Y.
James Eaton Tórrey, Montclair, N. J.
Richard William Tull, Philadelphia, Pa.
William Preston Wooten, Washington, D. C.

As Associates.

Samuel Fischer Miller, New York City.
Charles Louis Spier, New York City.

The Secretary announced:

The transfer of the following candidates, by the Board of Direction, on May 2d, 1905:

From Associate Member to Member.

Alfred Douglas Flinn, New York City.
John Flynn, Jr., Troy, N. Y.
Charles Wellford Leavitt, Jr., New York City.
Edson Mason Scofield, Philadelphia, Pa.
Henry Felix Wilson, Jr., Birmingham, Ala.

The election of the following candidates, by the Board of Direction:

As Juniors.

On February 28th, 1905.
  Joseph Carl Schaeffler, Somerville, Mass.
On April 4th, 1905.
  Arthur Clarence Tozzer, New York City.
On May 2d, 1905.
  Ernest Stearns Ball, New York City.
  John Clyde Fruit, New York City.
  Linn Murdoch Huntington, Culebra, Canal Zone, Panama.
  Harry George Raschbacher, Washington, D. C.
  Carl Howell Reeves, Seattle, Wash.
  Albert Orange Smith, Livingston Manor, N. Y.
  Roy Adolf Swartwout, Tecumseh, Nebr.

The Secretary announced the following death:

Shukichi Fujino, elected Junior February 3d, 1903; date of death unknown.

Adjourned.

May 17th, 1905.—The meeting was called to order at 8.30 p. m.; President C. C. Schneider in the chair; Assistant Secretary T. J. McMinn acting as Secretary; and present, also, 122 members and 32 guests.

A paper, by F. E. Trask, M. Am. Soc. C. E., entitled "The Irrigation System of Ontario, California—Its Development and Cost," was presented by the Acting Secretary.

G. B. Francis, M. Am. Soc. C. E., gave a description of "The Hydro-electric Development for the Atlanta Water and Electric Power Company, on the Chattahoochee River, near Atlanta, Ga.," illustrated with lantern slides, and the subject was discussed by Messrs. John Bogart, Wm. B. Parsons, Cary T. Hutchinson and G. B. Francis.

An oil painting of the late George S. Morison, Past-President, Am. Soc. C. E., was presented to the Society by William Barclay Parsons, M. Am. Soc. C. E., on behalf of certain of his friends who had subscribed to its cost.

The Acting Secretary announced the following deaths:

William Smith Morison, elected Associate Member April 6th, 1904; died May 1st, 1905.

Edmund Trowbridge Dana Myers, elected Member May 2d, 1888; died May 12th, 1905.

Adjourned.

OF THE BOARD OF DIRECTION.

(Abstract.)

April 20th, 1905.—A Special Meeting, for the consideration of tenders for the alterations and additions to the Society building, was held at 8.30 P. M., President Schneider in the chair; Chas. Warren Hunt, Secretary; and present, also, Messrs. Bowman, Craven, Davison, Deyo, Ellis, Knap, Landreth, N. P. Lewis, Noble, and Osgood.

Five tenders were received.

The President and Secretary were authorized to execute a contract with any of these bidders after having secured the approval of the Building Committee, and the Treasurer was authorized to make all necessary payments under such contract after they had been certified by the architect, and approved by the Building Committee.

Adjourned.

May 2d, 1905.—President Schneider in the chair; Chas. Warren Hunt, Secretary, and present, also, Messrs. Bissell, Bowman, Craven, Deyo, Gowen, Knap, Kuichling, N. P. Lewis, Noble, Osgood, Sherrerd and Webster.

Mr. Noble, Chairman of the Building Committee, reported that that Committee had approved the award of a contract for the addition to, and alterations of, the present House of the Society, to William L. Crow, the lowest bidder, the total amount of the contract being Fifty-two thousand four hundred and ninety-seven dollars ($52,497).

A report of the Board of Direction, for presentation to the Society at the next Annual Convention, in the matter of resolutions referred to the Board by the last Annual Meeting, was adopted.

Applications were considered, and other routine business transacted.

Five Associate Members were transferred to Member, and seven candidates for Junior were elected.

Adjourned.

Correction of Abstract of Minutes of the Meeting of the Board of Direction of April 4th, 1905:

In the third line, page 174 (April *Proceedings*) strike out "Craven" and insert "Croes."

ANNOUNCEMENTS.

The House of the Society is open from 9 A. M. to 10 P. M. every day, except Sundays, Fourth of July, Thanksgiving Day and Christmas Day.

MEETINGS.

Wednesday, June 7th, 1905.—8.30 P. M.—A regular business meeting will be held. Ballots for membership will be canvassed, and two papers will be presented for discussion, as follows: "A Few Points in the Design of Reinforced Concrete Arches," by B. R. Leffler, Assoc. M. Am. Soc. C. E., and "Theory of the Spherical or Conical Dome of Reinforced Concrete or Metal," by William Cain, M. Am. Soc. C. E.

Both these papers were printed in *Proceedings* for April, 1905.

Wednesday, September 6th, 1905.—8.30 P. M.—A regular business meeting will be held. Ballots for membership will be canvassed, and a paper, by Edwin H. Warner, M. Am. Soc. C. E., entitled "The Hydraulic Plant of the Puget Sound Power Company," will be presented for discussion.

This paper is printed in this number of *Proceedings.*

Wednesday, September 20th, 1905.—8.30 P. M.—At this meeting a paper entitled "Notes on the Improvement of River and Harbor Outlets in the United States," by D. A. Watt, M. Am. Soc. C. E. will be presented for discussion.

This paper is printed in this number of *Proceedings.*

ANNUAL CONVENTION.

The Thirty-Seventh Annual Convention will be held in Cleveland, Ohio, June 20th-23d, 1905. The following Committees have been appointed to take charge of the arrangements:

COMMITTEE OF THE BOARD OF DIRECTION:

ALFRED CRAVEN, *Chairman;*

N. P. LEWIS,
W. J. WILGUS,
CHARLES S. GOWEN,
CHAS. WARREN HUNT.

LOCAL COMMITTEE:

A. MORDECAI, *Chairman;*

WM. J. CARTER,
HARRY FULLER,
E. A. HANDY,
A. M. JOHNSTON,
M. W. KINGSLEY,
J. FRANCIS LE BARON,
F. C. OSBORN,
W. P. RICE,
J. RITCHIE,
W. H. SEARLES,
S. T. WELLMAN,
C. H. WRIGHT.

under the direction of this Committee, which were approved by the Board of Direction on April 5th, 1905, and on May 2d, 1905, a contract for the work was signed with Wm. L. Crow.

The contract calls for a building practically covering the entire new lot, of the same height as the present house, thus adding 50% to its capacity. The quality of work is to be in all respects similar to that of the old house.

The alterations will consist in remodeling the first floor, making a large Reception Hall, improving the entrance to the Lounging Room, enlarging the General Toilet Room, etc.

The plans also call for a stairway in the rear, furnishing direct communication between the Lounging Room on the first and the Auditorium on the second floor. These two rooms will be 50% larger than at present, the seating capacity of the Auditorium being increased from 400 to 600. The plans are so arranged that a large increase in space for office or library work can be readily made whenever required in the future, without altering the front part of the building.

The property of the Society now consists of a plot, the general dimensions of which are:

Frontage on Fifty-seventh Street...........	75 ft.
Depth on the east line.....................	107 "
" " " west line	118 "
Total area	8 437 sq. ft.

Building operations have already been begun by the contractor, and it is hoped to have the building so far advanced that the first fall meeting (September 6th, 1905) may be held in the new Auditorium.

LOCAL ASSOCIATIONS OF MEMBERS OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS.

The subject of the formation of Local Associations of the membership of the Society has been set down for discussion at the Annual Convention at Cleveland, and the present state of the matter is given below for the information of Members.

The following circular note, enclosing suggested By-Laws, was mailed March 7th, 1905, to at least three Members of the Society in each of the following cities, with a request that the suggestion be brought to the attention of Members in their vicinity.

Albany and Troy, N. Y.
Boston, Mass.
Cleveland, Ohio.
Chicago, Ill.
Detroit, Mich.
Kansas City, Mo.
Mexico, Mexico.
New Orleans, La.
Philadelphia, Pa.
Pittsburg, Pa.
St. Louis, Mo.
St. Paul and Minneapolis, Minn.
San Francisco, Cal.
Washington, D. C.

VIEWS OF THE BOARD OF DIRECTION AS TO THE FORMATION OF LOCAL ASSOCIATIONS OF MEMBERS OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS, MARCH, 1905.

The proposed formation of a Local Association of the Membership of the Society in Washington, D. C., has led the Board to a careful consideration of the desirability of such Associations in all localities in which the membership available for such purpose is sufficient in number.

The subject of the formation of local chapters of the Society was considered a number of years ago, but nothing was accomplished in this direction, as there developed considerable opposition to the formation of such chapters.

The present suggestion is understood to have a somewhat different end in view, *viz.*, the formation of local associations of our members for professional and social intercourse only. Similar propositions have been considered somewhat informally by the Board of Direction heretofore, one emanating from members residing in the City of Mexico, and another from St. Louis, although the latter proposition was merely the decision of the question as to whether the present local engineering society of St. Louis could be furnished, upon request, with certain of the Society publications, and allowed to discuss them with the privilege of having such discussion, if valuable, published by the Society. This latter question was decided by the Board in the affirmative, but nothing further has been heard from our members in that city.

The Board recommends that, wherever possible, steps be taken calling the attention of the membership to this matter, and that such Associations be formed.

In making this recommendation, the Board wishes to point out that associations of this character would be of great advantage to the Profession in general, and would widen greatly the influence of this Society, and enhance its standing in the various communities; that if coincidentally (or practically so) the papers issued in our *Proceedings* could be brought up for discussion at meetings in various localities and the resulting discussion forwarded to the Secretary of the Society for publication, subject to the rules in force in regard to the discussions which now take place in New York, it would result in great advantage to the *Transactions*, and that, in nearly all cases, it would be possible for the author of a paper published by the Society to be within reasonable traveling distance of some point at which his paper is to be read, and give him an opportunity to present it in person.

It is further believed that if this project can be carried out successfully, it would bring non-resident members into closer touch with all the work of the Society, and place the non-resident member practically in the position of a resident member of the Society in the particular locality in which he lives.

It is further submitted that the advantages to engineers who are not now members of the Society would be very great, and that the formation of such an association in any city would not interfere in any way with existing local engineering societies or clubs.

The Board has prepared a draft of proposed By-Laws for such an association (copy enclosed herewith), which, in its opinion, would be satisfactory.

Referring to this draft, it is believed that the following Articles: No. 1, relating to the Name, Location and Object; No. 2, relating to Membership, and No. 6, relating to Amendments, should in substance be incorporated in the By-Laws of all such associations, but that Article No. 3, relating to Dues; No. 4, relating to Officers, and No. 5, relating to Meetings, may all be varied in detail according to special local requirements or convenience.

These are inserted in the draft as suggestions for consideration in each special case, although it would be well if, in all matters except the amount of dues, all such associations had exactly similar By-Laws.

In this connection it should be noted that the Resident Membership of the Society pays an additional fee of $10 per annum for the special privileges of such membership, and that a much less yearly sum would probably suffice for the dues in Local Associations as outlined herein.

By order of the Board of Direction.
CHAS. WARREN HUNT,
Secretary.

PROPOSED BY-LAWS FOR LOCAL ASSOCIATIONS.

ART. I. NAME, LOCATION AND OBJECT.

(1) The name of this Association shall be the ...... Association of Members of the American Society of Civil Engineers.

(2) The offices of the Association shall be located in the City of ....

(3) Its objects shall be the advancement of engineering knowledge and practice, the maintenance of a high professional standing among its members, and the furtherance of the general welfare of the American Society of Civil Engineers.

(4) Among the means to be employed for these purposes shall be: Meetings for the presentation and discussion of professional papers, particularly those issued by the American Society of Civil Engineers, and the encouragement of engineers who are not members to attend and take part in the professional and social features of such meetings.

ART. II. MEMBERSHIP.

(1) The membership of this Association shall be restricted to persons who are members of the American Society of Civil Engineers in any grade and who reside within .... miles of .... All such may become members of this Association without payment of Entrance Fee, but should the membership in the American Society of Civil Engineers of any person cease from any cause, he shall at the same time cease to be a Member of this Association.

ART. III. DUES.

(1) The annual dues payable by all members shall be ......, payable semi-annually in advance on the first days of January and

July, and any member whose dues are more than six months in arrears shall cease to be a Member of this Association.

ART. IV. OFFICERS.

(1) The officers of the Association shall be a President, two Vice-Presidents, a Secretary, and a Treasurer, who shall constitute a Board of Directors, in which the government of the Association shall be vested.

(2) The term of office of the President of the Association shall be one year; of the Vice-Presidents, Secretary and Treasurer, two years. The term of each officer shall begin at the close of the Annual Meeting at which such officer is elected, and shall continue for the period above named, or until a successor is duly elected.

(3) A vacancy in any office shall be filled by election at the next regular meeting of the Association.

(4) The officers shall be elected at the Annual Meeting of the Association.

ART. V. MEETINGS.

(1) The Annual Meeting of the Association shall be held on the third Wednesday of December in each year.

(2) Regular meetings shall be held monthly, except during the summer months, at such time and place as may be appointed by the Board of Directors. At these meetings the business of the Association shall be transacted, and the discussion of professional papers published by the American Society of Civil Engineers, or specially prepared for the occasion, shall be in order. Such discussions may be furnished to the Secretary of the American Society of Civil Engineers for publication, subject to the approval of the Publication Committee of that Society.

ART. VI. AMENDMENTS.

(1) This Constitution may be amended only by a two-thirds vote of all members of the Association, which vote may be taken, if necessary, by letter-ballot, provided such amendment shall have previously received the approval of the Board of Direction of the American Society of Civil Engineers.

The subject seems to have aroused great interest among the Members of the Society generally, and two Local Associations have already been formed.

Kansas City, Mo.—The Kansas City Association of Members of the American Society of Civil Engineers was organized on April 8th, 1905, the following officers being elected:

President, Daniel Bontecou.

Vice-Presidents, I. G. Hedrick, S. W. Fox.

Secretary and Treasurer, C. S. Burns.

The membership is limited to the membership of the Society residing within 100 miles of Kansas City; the annual dues are not to exceed $10; meetings are to be held monthly, except during June, July and August.

San Francisco, Cal.—The San Francisco Association of Members of the American Society of Civil Engineers was organized on April 28th, 1905, the following officers being elected:

President, Captain Wm. W. Harts.
Vice-Presidents, G. E. Gray, C. D. Marx.
Secretary, F. Riffle.
Treasurer, A. L. Adams.

To a circular letter, which was addressed to 79 members living within 100 miles of San Francisco, by Captain Harts, 55 replies were received, all but two of which were favorable to the organization; 29 members were present at the meeting of April 28th, and it is stated by the President that there was considerable enthusiasm manifested. The 100-mile limit for membership was adopted; dues were fixed at not more than $5 per year. The Annual Meeting is to be held on the third Wednesday of December of each year, and regular meetings are to be held bi-monthly.

Washington, D. C.—In this city, where this movement started, there has been much discussion of the subject, but no decision has been reached.

Cleveland, Ohio.—The matter is still under consideration, the reports at present indicate favorable action by our members in that vicinity; the sense of a meeting held on April 11th, 1905, at which 15 were present, was expressed that such an association would be desirable.

Philadelphia, Pa.—The matter is to be submitted to letter-ballot of the local membership.

Pittsburg, Pa.—It was the intention to have a meeting for the consideration of this matter on May 10th, but, upon the understanding that the whole question would be discussed at the Convention, action has been deferred.

Boston, Mass.—The statement is made that it is the unanimous opinion of those who have been consulted that it would be very difficult to arouse sufficient enthusiasm in Boston and vicinity to result in such an organization.

St. Louis, Mo.—At a meeting of the St. Louis members, held on March 24th, 1905, a resolution was adopted to the effect that it is not desirable at this time to have such an organization in St. Louis. There were 23 members present. There is now a local organization of our members, which has, to date, held 26 meetings, but has never met for the purpose of reading or discussing technical papers, but only for the discussion of business matters in connection with the National Society.

There has been more or less correspondence with members in the other cities to whom the suggestion was sent, but nothing definite has been decided.

ACCESSIONS TO THE LIBRARY.

From April 12th to May 9th, 1905.

DONATIONS.*

FABRICATION DE L'ACIER.

Par H. Noble. Paper, 10 x 6 in., illus., 7 + 603 pp. Paris, Vve. Ch. Dunod. 26 francs, 50 centimes.

The preface states that this work gives first, in a condensed form, the properties of iron; especially applied in iron and steel work; then the different processes of manufacturing bars of steel, for the rolling mill and the forge, are minutely studied from the theoretical and especially the practical point of view. The study of methods of manufacture is made from the side of the metal and also of the accessory materials and preparation. It is intended to be a complete guide to the overseer and engineer in charge of steel works. The last chapter describes the organization of the working force, also technical bookkeeping; this includes not only the cost and returns for the bar of steel but also for the different intermediary conditions of the metal. Various usages are given, and the numerous examples are chosen from the arrangements that are the best known and the most complete. There is an index of about ten pages.

DIE FORMELZEICHEN.

Ein Beitrag zur Lösung der Frage der algebräischen Bezeichnung der physikalischen, technischen und chemischen Grössen. Von Olof Linders. Paper, 11 x 7 in., 96 pp. Leipzig, Jäh & Schunke, 1905.

Since the appearance of his book "Die physikalischen Grössen," the author states that the interest in the question of signs has grown so great that it might now be attempted to treat the matter further in a separate volume, and this is the reason for this little book, in which he adds three more propositions as a contribution to the solution of this most important, but very difficult question. He has at the same time inserted for comparison the signs occurring in several of the much-used technical handbooks, and, moreover, as far as space permitted, some of the most important sign propositions so far known. The chief feature of the book is a large table giving 871 quantities used in physics, electricity, chemistry, etc., each followed by the various letter symbols proposed to represent it.

DESCRIPTIVE GEOMETRY FOR STUDENTS OF ENGINEERING.

By James Ambrose Moyer. Second edition. Cloth, 9 x 6, illus., 8 + 198 pp. New York, John Wiley & Sons, 1905. $2.

The preface states that the aim of this book is to present the subject so as to make it most easily applicable to the requirements of recent engineering practice. It is alleged that the methods of presentation, therefore, are not traditional. Experience has shown that most students in our best technical schools have difficulty in applying their knowledge of this subject to subsequent work in structural and machine design. Two things have been attempted to overcome this failure; the notation is essentially the same as that used in mechanical drawing, and many concrete exercises, showing usual practical applications have been inserted. The data for the exercises are stated by the system of coördinates used in analytic geometry; a large number of perspective and orthographic drawings have been inserted.

Gifts have also been received from the following:

Albany, N. Y.—R. R. Commrs. 2 bound vol.
Am. Assoc. 1 pam.
Am. Ry. Assoc. 1 pam.
Assoc. Propriétaires d'Appareils à Vapeur. 1 vol.
Augusta, Ga.—Mayor. 1 pam.
Bates, L. W. 1 pam.
Brockton, Mass.—Water Commrs. 1 pam.
Brooklyn Engrs.' Club. 1 bound vol.
Burlington, Vt.—City Clerk. 1 pam.
Byllesby, H. M., & Co. 1 bound vol.
Canada—Dept. of Marine and Fisheries. 1 pam.
Canada—Dept. of Rys. & Canals. 1 vol.
Canadian Min. Inst. 2 vol., 1 pam.
Colo.—Agri. Exper. Station. 4 pam.
Fisk, W. L. 1 vol.

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*Unless otherwise specified, books in this list have been donated by the publishers.

France—Ministère de Travaux Publics. 1 pam.
Gloversville, N. Y.—Water Board. 1 pam.
Great Brit.—Patent Office. 13 pam., 4 vol.
Hale, H. E. 1 bound vol.
Harrington, J. L. 1 bound vol.
Hartford—Board of Street Commrs. 1 pam.
Hill, C. R. 1 bound vol.
Hill, J. W. 1 pam.
Holyoke, Mass.—City Engr. 1 pam.
Inst. of Mech. Engrs. 1 vol.
Iowa Eng. Soc. 1 pam.
Mass.—Bureau of Labor. 1 bound vol.
Met. Park Com. 2 bound vol.
Mich.—State Board of Health. 8 pam.
Mich. Central R. R. Co. 1 pam.
Miss. River Comm. 1 pam.
New Jersey—Commr. of Public Roads. 1 vol.
New York Central & Hudson River R. R. Co. 1 pam.
New York, Chicago & St. Louis R. R. Co. 1 pam.
Nicholson, G. B. 1 pam.
Northampton, Mass.—Water Commrs. 1 pam.
Ontario—Provincial Board of Health. 1 pam.
Paine, Charles. 2 vol.
Permanent Inter. Assoc. of Navigation Cong. 1 vol.
Providence, R. I.—R. R. Commr. 1 bound vol.
Reform Club, 9 bound vol. 2 vol., 20 pam.
Rhode Island—Board of Public Roads. 1 bound vol.
Rose Polytechnic Inst. 1 vol.
Royal Soc. of New South Wales. 1 vol.
Schenectady, N. Y.—City Engr. 2 pam.
Shanghai, China—Mun. Council. 1 vol.
Soc. Belge des Ingenieurs et des Industriels. 2 pam.
Soc. des Ingenieurs Civ. de France. 1 vol.
Soper, G. A. 1 pam.
Taunton, Mass.—Water Dept. 1 pam.
Texas—R. R. Comm. 1 vol.
Thayer, Russel. 1 pam.
Unknown. 8 pam.
U. S. Bureau of Education. 1 bound vol.
U. S. Bureau of Forestry. 1 bound vol.
U. S. Bureau of Statistics. 1 bound vol., 1 vol., 1 pam.
U. S. Bureau of the Census. 1 bound vol.
U. S. Geol. Surv. 4 pam.
U. S. Interstate Commerce Comm. 4 pam.
U. S. War Dept. 15 Specif.
Univ. of Ill. 3 pam.
Univ. of Mich. 1 pam.
Univ. of Wis. 1 bound vol.
Van Sandick, R. A. 1 pam.
Vernon-Harcourt, L. F. 2 pam.

BY PURCHASE.

Manuel Pratique des Moteurs à Gaz et Gazogènes. Par R. E. Mathot. Paris, Ch. Béranger, 1904.

Die deutschen Städte. Von Robert Wuttke. Band 1-2. Leipzig, Freidrich Brandstetter, 1904.

Problems of the Panama Canal. By Henry L. Abbot. New York, The Macmillan Company, 1905.

Tables for Roof Framing, etc. Revised and extended with Logarithms of 32ds from zero to 60 feet; Sines, Tangents, etc., for Draughtsmen. By G. D. Inskip, Philadelphia, 1904.

A Manual of Mining. Based on the Course of Lectures on Mining, Delivered at the School of Mines of the State of Colorado. By M. C. Ihlseng and Eugene B. Wilson. New York, John Wiley & Sons; London, Chapman & Hall, Limited, 1905.

Modern Civic Art; or, The City Made Beautiful. By Charles Mulford Robinson. G. P. Putnam's Sons, New York and London. 1904.

The Art of Generating Gear-Teeth. By Howard A. Coombs. New York, D. Van Nostrand Company, 1904.

Generator-Kraftgas- und Dampfkessel-Betrieb, in Bezug auf Wärmeerzeugung und Wärmeverwendung. Eine Darstellung der Vorgänge, der Untersuchungs- und Kontrollmethoden bei der Umformung von Brennstoffen für den Generator-Kraftgas- und Dampfkessel-Betrieb. Von Paul Fuchs. Berlin, Julius Springer, 1905.

Die Steuerungen der Dampfmaschinen. Von Carl Leist. Berlin, Julius Springer, 1905.

SUMMARY OF ACCESSIONS.

April 12th to May 9th, 1905.

Donations (including 7 duplicates)	158
By purchase	9
Total	167

MEMBERSHIP.

ADDITIONS.

MEMBERS.

		Date of Membership.
BERRY, GEORGE. 78 Morton St., Brooklyn, N. Y.		May 3, 1905
DAVENPORT, JAMES AUBREY. 418 Third St., S. W., Roanoke, Va.		April 5, 1905
DOBLE, WILLIAM ASHTON. 200 Fremont St., San Francisco, Cal.		April 5, 1905
EASTERBROOK, FREDERICK JAMES. 82 York Sq., New Haven, Conn.		May 3, 1905
ENDO, TOKICHI. Chf. Engr., Nankai Ry. Co., Osaka, Japan.		Feb. 1, 1905
FLINN, ALFRED DOUGLAS. Gen. Insp., Aqueduct Commrs., 280 Broadway, New York City.	Assoc. M. M.	Dec. 6, 1899 May 2, 1905
FLYNN, JOHN, Jr. Civ. and Elec. Engr.; City Engr., 83 Third St., Troy, N. Y.	Assoc. M. M.	Jan. 8, 1903 May 2, 1905
GUNN, WILLIAM EDWARD. City Engr., Covington, Ky.		April 5, 1905
JAMIESON, JAMES ALEXANDER. Cons. and Designing Engr., Board of Trade Bldg., Montreal, Qué., Canada		May 3, 1905
JAPP, HENRY. Managing Engr. and Director, S. Pearson & Son, Inc., Long Island City, N. Y.		May 3, 1905
LEAVITT, CHARLES WELLFORD, Jr. Civ. and Landscape Engr., 15 Cortlandt St., New York City.	Assoc. M. M.	Jan. 4, 1898 May 2, 1905
MEEM, JAMES COWAN. Chf. Engr. for Cranford & McNamee, 52 Ninth St. (Res., 177 Woodruff Ave.), Brooklyn, N. Y.	Assoc. M. M.	April 1, 1896 April 4, 1905
MOORE, JOHN EDWIN. 1121 The Rookery, Chicago, Ill.		Oct. 5, 1904
SCOFIELD, EDSON MASON. Pres. and Chf. Engr., The Scofield Co., Cons. and Contr. Engrs., Pennsylvania Bldg., Philadelphia, Pa.	Assoc. M. M.	April 1, 1896 May 2, 1905
SEWELL, JOHN STEPHEN. Capt., Corps of Engrs., U. S. A., P. O. Box 455, Washington, D. C.		April 5, 1905
VAN KEUREN, CHARLES AUGUSTUS. Chf. Engr., Municipality of Jersey City, 53 Clinton Ave., Jersey City, N. J.		May 3, 1905

ASSOCIATE MEMBERS.

BANNISTER, CARL LINCOLN. Barge Canal Office, Rome, N. Y.	May 3, 1905
BLAKE, CARROLL. 154 Eightieth St., Brooklyn, N. Y.	May 3, 1905

		Date of Membership.
Brush, William Whitlock. Asst. Engr., Dept. of Water Supply, Gas and Electricity, Room 41, Municipal Bldg., Brooklyn, N. Y.	Jun. Assoc. M.	Mar. 3, 1896 April 5, 1905
Dater, Philip Herrick. Asst. Engr., Barge Canal Office, DeGraaf Bldg. (Res., 116 Lancaster St.), Albany, N. Y.		April 5, 1905
Finley, Edwin Clifford. 523 Chemical Bldg., St. Louis, Mo.		April 5, 1905
Getman, Frank Lawton. 14 Catherine St., Lyons, N. Y.		April 5, 1905
Guthrie, Keith Osmond. 434 Greene Ave., Brooklyn, N. Y.		May 3, 1905
Haney, Lewis Tustler. 369 Ocean Ave., Brooklyn, N. Y.	Jun. Assoc. M.	Oct. 7, 1902 Mar. 1, 1905
Herring, Jerome Campbell. City Engr., Jefferson City, Mo		April 5, 1905
Hudson, Harold Walton. 826 North 3d St., Harrisburg, Pa.		May 3, 1905
Lavalle, Louis Ralph. With Arthur Koppel, Ltd., P. O. Box 3256, Johannesburg, South Africa		Feb. 1, 1905
Lobo, Carlos. 441 Third St., Brooklyn, N. Y.		May 3, 1905
Lochridge, Elbert Emerson. Engr., Water Dept., 43 Bridge St., Springfield, Mass		May 3, 1905
Roberts, Shelby Saufley. Roadmaster and Asst. Engr., Louisville Terminals, L. & N. R. R. (Res., 1604 Second St.), Louisville, Ky		April 5, 1905
Searle, Charles Depew. Asst. Engr., Rapid Transit Comm., 40 West 127th St., New York City		April 5, 1905
Torrey, James Eaton. Asst. Engr., C. R. R. of N. J., Jersey City, N. J		May 3, 1905
Tull, Richard William. Asst. Engr. in office of C. C. Schneider, 15th and Chestnut Sts., Philadelphia, Pa.		May 3, 1905
Walters, Henry Radclyffe St. Arvans. Prin. Asst. Engr. and Chf. Draftsman, Guerber Eng. Co. (Res., 211 South New St.), Bethlehem, Pa.	Jun. Assoc. M.	Oct. 6, 1903 April 5, 1905
Wooten, William Preston. Capt., Corps of Engrs., U. S. A., 2728 Pennsylvania Ave., Washington, D. C.		May 3, 1905
Wrentmore, Clarence George. Asst. Prof. of Civ. Eng., Univ. of Mich., Ann Arbor, Mich		April 5, 1905

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Quilty, Thomas Frank. Care, John J. O'Heron & Co., 6 Wabash Ave., Chicago, Ill	April 5, 1905
Scribner, Gilbert Hilton, Jr. 440 Chestnut St., Chicago, Ill	April 5, 1905
Spier, Charles Louis. 26 Broadway, New York City	May 3, 1905

JUNIORS.

	Date of Membership.
Ball, Ernest Stearns. 202 West 81st St., New York City	May 2, 1905
Barnard, Elmer Ellsworth. 414 Fifth Ave., Lynchburg, Va	Jan. 31, 1905
Doty, Arden Duane. 35 Warren St., New York City	April 4, 1905
Fisher, Wilbur Howard. 158 Market St., Hannibal, Mo.	Dec. 6, 1904
Hunter, Thomas Benton. Res. Engr., Pacific Impvt. Co.'s Water Works, Monterey, Cal	April 4, 1905
Lewis, Samuel James. Care, U. S. Geological Survey, Hydrographic Branch, Washington, D. C	Dec. 6, 1904
Lydston, Walter Edward. Asst. Engr., Lehigh Val. R. R., 12 James St., Auburn, N. Y	April 4, 1905
Owens, James Michael. Dept. of Public Works, City Hall, San Francisco, Cal	April 4, 1905
Schaeffler, Joseph Carl. 49 Laurel St., Somerville, Mass	Feb. 28, 1905
Whitaker, William Franklin. Box 252, Bakersfield, Cal	April 4, 1905
Wilson, James Arthur. 205 Park Pl., Brooklyn, N. Y	Sept. 6, 1904

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Conkling, Cloud Clifford. Cons. Civ. Engr., 834 Ellicott Sq., Buffalo, N. Y.

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DIEHR, ALVAH BENJAMIN. Route 4, Nevada, Mo.

DUNCAN, LINDSAY. Engr., Taylor-Moore Constr. Co., Cedar Creek, Colo.

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HALLIHAN, JOHN PHILIP. Asst. to Pres. and Chf. Engr., Ferrocarril Rio Grande, Sierra Madre y Pacifico, S. A., P. O. Box 687, El Paso, Tex.

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LEPPER, FRED WILLIAM. Supt., Constr., U. S. Post Office, Custom House and Court House, 504 Chamber of Commerce Bldg., Cleveland, Ohio.

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DEATHS.

JUNIORS.

SHUKICHI, FUJINO. Elected Junior February 3d, 1903; date of death unknown.

MONTHLY LIST OF RECENT ENGINEERING ARTICLES OF INTEREST.

(April 9th, 1905, to May 6th, 1905.)

NOTE.—*This list is published for the purpose of placing before the members of the Society, the titles of current engineering articles, which can be referred to in any available engineering library, or can be procured by addressing the publication directly, the address and price being given wherever possible.*

LIST OF PUBLICATIONS.

In the subjoined list of articles references are given by the number prefixed to each journal in this list.

(1) *Journal*, Assoc. Eng. Soc., 257 South Fourth St., Philadelphia, Pa., 30c.
(2) *Proceedings*, Engrs. Club of Phila., 1122 Girard St., Philadelphia, Pa.
(3) *Journal*, Franklin Inst., Philadelphia, Pa., 50c.
(4) *Journal*, Western Soc. of Engrs., Monadnock Block, Chicago, Ill.
(5) *Transactions*, Can. Soc. C. E., Montreal, Que., Canada.
(6) *School of Mines Quarterly*, Columbia Univ., New York City, 50c.
(7) *Technology Quarterly*, Mass. Inst. Tech., Boston, Mass., 75c.
(8) *Stevens Institute Indicator*, Stevens Inst., Hoboken, N. J., 50c.
(9) *Engineering Magazine*, New York City, 25c.
(10) *Cassier's Magazine*, New York City, 25c.
(11) *Engineering* (London), W. H. Wiley, New York City, 25c.
(12) *The Engineer* (London), International News Co., New York City, 35c.
(13) *Engineering News*, New York City, 15c.
(14) *The Engineering Record*, New York City, 12c.
(15) *Railroad Gazette*, New York City, 10c.
(16) *Engineering and Mining Journal*, New York City, 15c.
(17) *Street Railway Journal*, New York City, 35c.
(18) *Railway and Engineering Review*, Chicago, Ill., 10c.
(19) *Scientific American Supplement*, New York City, 10c.
(20) *Iron Age*, New York City, 10c.
(21) *Railway Engineer*, London, England, 25c.
(22) *Iron and Coal Trades Review*, London, England. 25c.
(23) *Bulletin*, American Iron and Steel Assoc., Philadelphia, Pa.
(24) *American Gas Light Journal*, New York City, 10c.
(25) *American Engineer*, New York City, 20c.
(26) *Electrical Review*, London, England.
(27) *Electrical World and Engineer*, New York City, 10c.
(28) *Journal*, New England Water-Works Assoc., Boston, $1.
(29) *Journal*, Society of Arts, London, England, 15c.
(30) *Annales des Travaux Publics de Belgique*. Brussels, Belgium.
(31) *Annales de l'Assoc. des Ing. Sortis des Ecoles Speciales de Gand*. Brussels, Belgium.
(32) *Memoires et Compte Rendu des Travaux*, Soc. Ing. Civ. de France, Paris, France.
(33) *Le Genie Civil*, Paris, France.
(34) *Portefouille Economique des Machines*, Paris, France.
(35) *Nouvelles Annales de la Construction*, Paris, France.
(36) *La Revue Technique*, Paris, France.
(37) *Review de Mecanique*, Paris, France.
(38) *Revue Generale des Chemins de Fer et des Tramways*, Paris, France.
(39) *Railway Master Mechanic*, Chicago, Ill., 10c.
(40) *Railway Age*. Chicago, Ill., 10c.
(41) *Modern Machinery*, Chicago, Ill., 10c.
(42) *Transactions*, Am. Inst. Elect. Engrs., New York City, 50c.
(43) *Annales des Ponts et Chaussees*, Paris, France.
(44) *Journal*, Military Service Institution, Governor's Island, New York Harbor, 50c.
(45) *Mines and Minerals*, Scranton, Pa., 20c.
(46) *Scientific American*, New York City, 8c.
(47) *Mechanical Engineer*, Manchester, England.
(48) *Zeitschrift*, Verein Deutscher Ingenieure, Berlin, Germany.
(49) *Zeitschrift für Bauwesen*, Berlin, Germany.
(50) *Stahl und Eisen*, Düsseldorf, Germany.
(51) *Deutsche Bauzeitung*, Berlin, Germany.
(52) *Rigasche Industrie-Zeitung*, Riga, Russia.
(53) *Zeitschrift*, Oesterreichischer Ingenieur und Architekten Verein, Vienna, Austria.
(54) *Transactions*, Am. Soc. C. E., New York City, $5.

(55) *Transactions*, Am. Soc. M. E., New York City, $10.
(56) *Transactions*, Am. Inst. Min. Engrs., New York City, $5.
(57) *Colliery Guardian*, London, England.
(58) *Proceedings*, Eng. Soc. W. Pa., 410 Penn Ave., Pittsburg, Pa., 50c.
(59) *Transactions*, Mining Inst. of Scotland, London and Newcastle-upon-Tyne, England.
(60) *Municipal Engineering*, Indianapolis, Ind., 25c.
(61) *Proceedings*, Western Railway Club, 225 Dearborn St., Chicago, Ill., 25c.
(62) *American Manufacturer and Iron World*, 59 Ninth St., Pittsburg, Pa.
(63) *Minutes of Proceedings*, Inst. C. E. London, England.
(64) *Power*, New York City, 20c.
(65) *Official Proceedings*, New York Railroad Club, Brooklyn, N. Y., 15c.
(66) *Journal of Gas Lighting*, London, England, 15c.
(67) *Cement and Engineering News*, Chicago, Ill., 25c.
(68) *Mining Journal*, London, England.
(69) *Mill Owners*, New York City, 10c.
(70) *Engineering Review*, New York City, 10c.
(71) *Journal*, Iron and Steel Inst., London, England.
(72) *Street Railway Review*, Chicago, 30c.
(73) *Electrician*, London, England, 18c.
(74) *Transactions*, Inst. of Min. and Metal., London, England.
(75) *Proceedings*, Inst. of Mech. Engrs., London, England.
(76) *Brick*, Chicago, 10c.
(77) *Journal*, Inst. Elec. Engrs., London, England.
(78) *Beton und Eisen*, Vienna, Austria.
(79) *Forscherarbeiten*, Vienna, Austria.
(80) *Tonindustrie-Zeitung*, Berlin, Germany.
(81) *Zeitschrift fur Architektur und Ingenieurwesen*, Wiesbaden, Germany.
(82) *Dinglers Polytechnisches Journal*, Berlin, Germany.

LIST OF ARTICLES.

Bridge.

Reinforced Concrete Culverts for Highways.* T. E. McDonald. (Paper read before the Cement Users' Assoc.) (67) Mar.; (60) May.
Concrete-Steel Arch Bridge at Kankakee, Illinois.* J. B. Marsh. (4) Apr.
An Attempt to Show Graphically the Deflections and Bending Moments in the Britannia Tubular Bridge as described in Clarke's Book, Vol. 11.* (21) Apr.
The Victoria Falls Bridge.* (12) Apr. 7; (14) Apr. 29.
The Cuyahoga Valley Viaduct.* G. H. Tinker. (15) Apr. 14.
An Australian Electrically Equipped Drawbridge.* (27) Apr. 15.
Strengthening Traction Bridges.* H. G. Tyrrell. (72) Apr. 15.
Erection of the Cambridge Bridge, Boston.* (14) Apr. 15.
A Shallow Solid-Floor Girder.* (15) Apr. 21.
Erection of the Bellows Falls Arch Bridge.* (14) Apr. 29.
The Southwestern Ave. Boulevard Nine-Track Viaduct in Chicago.* (14) Apr. 29.
The Lebanon Valley Double-Track Skew Plate-Girder Bridge.* (14) Apr. 29.
Making the Cables of a Large Suspension Bridge.* Isaac Harby, Assoc. M. Am. Soc. C. E. (10) May.
The Use of a Novel Water Jet for Driving Piles for the Sandy Hook Proving Ground Railroad Trestle.* Sherman A. Jubb. (13) May 4.
The Development in Railroad Bridge Design and Construction.* Henry W. Hodge. (15) May 5.
Die Neue Strassenbrücke über die Spree bei Oberschöneweide bei Berlin.* Karl Bernhard. (51) Serial beginning Mar. 31.
Eine 116m. Lange Balkenbrücke in Armiertem Beton, System Hennebique.* D. Goldenberg. (78) Apr.
Entwürfe für Eine Vereinigte Eisenbahn- und Strassenbrücke über die Oder bei Neusalz.* F. Dircksen. (48) Serial beginning Apr. 15.

Electrical.

Middlesbrough Dock Electric and Hydraulic Power Plant.* Vincent L. Raven, M. I. Mech. E. (75) No. 3, 1904.
Compensated Alternate Current Generators.* Miles Walker. (77) Vol. 34, Pt. 2.
The Combination of Dust Destructors and Electricity Works Economically Considered.* W. P. Adams, M. I. E. E. (77) Vol. 34, Pt. 2.
High-Tension Switchgear.* Leonard Andrews, M. I. E. E. (77) Vol. 34, Pt. 2.
Armature Reaction in Alternators.* James B. Henderson, M. I. E. E., and John S. Nicholson. (77) Vol. 34, Pt. 2.
Condensing Arrangements in Central Stations. J. D. Bailie, Assoc. M. I. E. E. (77) Vol. 34, Pt. 2.
The Magnetic Properties of Some Alloys of Iron and Silicon.* Thomas Baker. (77) Vol. 34, Pt. 2.
Hydro-Electric Power Development and Transmission in California. Robert McF. Doble. (1) Mar.

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Electrical—(Continued).

Weak Points in Long-Distance Electric Transmission. James C. Bennett. (1) Mar.
Bimetallic Rheostats.* F. Punga. (26) Mar. 31.
Underground Electrical Construction.* Louis A. Ferguson. (Abstract of Paper read before the International Elec. Cong.) (73) Mar. 31.
The Yarmouth-Gorleston Submarine Cable.* (73) Mar. 31.
Water-Power Plant for a Cordite Factory in India.* (12) Mar. 31.
The Present Status of Electric Furnace Working.* Charles F. Burgess. (4) Apr.
Notes on the Use of Rare Earths in Electric Illuminants.* Murray C. Beebe. (58) Apr.
Denny and Johnson's Torsion Meter.* (11) Apr. 7.
The 36,000-Volt Hydro-Electric Installation of the Cellina (Italy).* Enrico Bignami. (26) Apr. 7.
A New Motor-Starting Panel with Circuit Breaker for Individual Driving.* (17) Apr. 8.
Headworks of the Plant of the Toronto & Niagara Power Co., Niagara Falls.* (14) Apr. 8.
Largest Electric Water Power in Maine.* (27) Apr. 8.
The Power Installation of a Coffee-Roasting and Spice-Grinding Plant.* H. S. Knowlton. (27) Apr. 8.
Transformer Practice. C. W. Humphrey. (27) Apr. 8.
Flux Distribution in Design. A. Press. (27) Apr. 8.
On the Electrical Drive of Large Reversing Engines Working Intermittently.* Maurice Georgi. (Paper read before the Glasgow Technical College Scientific Soc.) (57) Serial beginning Apr. 14.
The Gersthofen Hydro-Electric Power Station.* (12) Apr. 14.
New Party-Line Telephone System.* (26) Apr. 14; (73) Apr. 14.
A New Underground Cable System.* Axel Hultman. (26) Apr. 14.
A New Oscillographic Wave Tracer.* Rudolf Goldschmidt. (73) Apr. 14.
Recent Experiments on the Nature of Magnetism.* Emile Guarini. (19) Apr. 15.
Single Wattmeter on Edison Three-Wire System. L. A. Freudenberger. (27) Apr. 15.
New American System of Wireless Telegraphy.* James Foster King. (27) Apr. 15.
The Starting of Rotary Converters.* Sydney Woodfield. (26) Apr. 21.
Electric Lighting of the Middleburg Cantonments, South Africa.* (26) Apr. 21.
The Church Stretton Gas-Driven Electricity Works.* (26) Apr. 21.
Electric Locomotive Cranes.* (12) Apr. 21.
The London Wall Telephone Exchange.* (73) Apr. 21.
2 700 Horse-Power Turbo-Alternator.* (12) Apr. 21.
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Westinghouse Direct-Current Power Distribution System.* (27) Apr. 22.
Nitric Acid in Insulation of High-Tension Alternator Coils. Charles E. Farrington. (27) Apr. 22.
Loss Due to Surplus Capacity in Transformers. J. S. Codman. (27) Apr. 22.
Artom Selective System of Wireless Telegraphy.* A. Frederick Collins. (27) Apr. 22.
Municipal Arc Lighting Plant in Columbus, Ohio.* C. Wiler. (27) Apr. 22.
The Slip of an Induction Motor.* B. F. Bailey. (27) Apr. 22.
The Metallic Arc.* Isador Ladoff. (27) Apr. 22.
A New Method of Testing Alternating-Current Generators.* H. M. Hobart and F. Punga. (27) Apr. 22.
The Fleming Cymometer. (24) Apr. 24.
The Sturtevant 100-Kw. Generating Set.* (20) Apr. 27.
New Storage Battery.* (15) Apr. 28; (14) Apr. 29; (17) Apr. 29; (27) Apr. 29; (13) May 4.
How to Remember the Wire Table. Charles F. Scott. (From *Electric Club Journal.*) (19) Apr. 29.
A Norwegian Hydro-Electric Plant.* T. Norberg Schulz. (27) Apr. 29.
The Practical Design of the Solenoid.* Charles R. Underhill. (27) Apr. 29.
Line Effects Due to a Moving Load.* Carl P. Nachod. (27) Apr. 29.
New Westinghouse Apparatus.* (27) Apr. 29.
The Cooper Hewitt Mercury Vapor Converter.* A. Frederick Collins. (46) Apr. 29.
Tesla Patent on Wireless Transmission of Electrical Signals.* (27) Apr. 29.
The Electric Railway Freight Service. H. H. Polk. (17) Apr. 29.
The Cutler-Hammer Magnetic Accelerator.* (41) May.
Alternating Current Switches.* (25) May.
A New Secret Service Telephone.* (19) May 6.
Le Matériel Thury à l'Usine de Vouvry (Valais-Suisse).* C. F. Guilbert. (36) Serial beginning Mar. 25.
Les Petits Groupes Électrogènes Considérés au Point de Vue de la Production Économique de l'Énergie Électrique. R. Friédérich. (36) Mar. 25.
Untersuchung des Auslaufweges Elektrischer Aufzüge. Hugo Stahl. (48) Apr. 8.
Die Tantal-Lampe. (82) Apr. 22.

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Marine.

Marine Engineering.* W. F. Durand, M. Am. Soc. M. E. (54) Vol. 54, Pt. C.

Marine Engineering in France. V. Daymard and R. Lelong. (Tr. from the French by Paul A. Seurot, M. Am. Soc. C. E.) (54) Vol. 54, Pt. C.

The *Discovery*: On the Design of the Antarctic Exploration Vessel *Discovery*.* W. E. Smith. (Paper read before the Inst. of Naval Archts.) (11) Apr. 14.

Electricity as Motive Power for 1 100-Ton Cargo-Boat.* J. W. H. Hamilton. (27) Apr. 15.

Model Experiments on Hollow *versus* Straight Lines.* R. E. Froude. (Paper read before the Inst. of Naval Archts.) (11) Apr. 21; Abstract (12) Apr. 21.

The Japanese Cruisers *Kasuga* and *Nisshin*.* N. Soliani. (Paper read before the Inst. of Naval Archts.) (11) Apr. 21.

Marine Gas Engine.* (12) Apr. 21.

The effect of Acceleration on Ship Resistance. C. E. Stromeyer. (Paper read before the Inst. of Naval Archts.) (11) Apr. 21.

A Method of Preventing Vibration in Steamships.* A. Mallock. (Paper read before the Inst. of Naval Archts.) (47) Apr. 22.

A Leadless Sounding Apparatus.* Alfred Gradenwitz. (46) Apr. 22.

The New First-Class Japanese Battleship *Kashima*.* Harold J. Shepstone. (19) Apr. 22.

New Masonry Drydock at the Boston Navy Yard.* (46) Apr. 29.

Mechanical.

The Manufacture of Cement.* R. W. Lesley, Assoc. Am. Soc. C. E. (54) Vol. 54, Pt. B.

Passenger Elevators.* Thomas E. Brown, M. Am. Soc. C. E. (54) Vol. 54, Pt. B.

Fuel Economy in Steam Power Plants.* William H. Booth and John B. C. Kershaw. (77) Vol. 34, Pt. 2.

The Curtis Steam-Turbine.* W. L. R. Emmet, Am. Soc. M. E. (75) No. 3, 1904.

Different Applications of Steam-Turbines.* A. Rateau. (75) No. 3, 1904.

Experiments with a Lathe-Tool Dynamometer.* J. T. Nicolson. (75) No. 3, 1904.

Some Theoretical and Practical Considerations in Steam-Turbine Work.* Francis Hodgkinson, Am. Soc. M. E. (75) No. 3, 1904.

The De Laval Steam-Turbine.* E. S. Lea, Am. Soc. M. E., and E. Meden. (75) No. 3, 1904.

Mixing Cement. R. G. Coutts. (Paper read before the Cement Users' Convention.) (67) Mar.

Suction Gas Producers.* (12) Serial beginning Mar. 31.

Rolling Mill Engines. Robert J. Worth. (Extracts from Address before the Cleveland Inst. of Engrs.) (22) Mar. 31.

Large Coal and Ash Handling Plant.* (22) Mar. 31.

The Hornsby Vertical Oil-Engine.* (11) Mar. 31.

The Diesel Oil Engine.* (12) Mar. 31.

Water-Coolers for Motor-Cars. J. S. V. Bickford. (11) Mar. 31.

Notes on Engineering Alloys. (11) Mar. 31.

A Rapid Production Vertical Turret Lathe.* (39) Apr.

Trip-Valve Motion for Steam Engines.* (47) Apr. 1.

Four-Cylinder Internal-Combustion Engine.* (47) Apr. 1.

Internal-Combustion Engines. Prof. Burstall. (Abstract of Lecture delivered before the Liverpool Univ. Eng. Soc.) (47) Apr. 1.

Ammoniacal Liquor and the Manufacture of Sulphate of Ammonia. R. L. Fenner. (Abstract of Paper read before the London and Southern District Junior Gas Assoc.) (66) Apr. 4.

Hydraulics as Applied at Present in Modern Gas Works, and Their Future Possible Application.* Richard Webster. (Abstract of Paper read before the Scottish Junior Gas Assoc.) (66) Apr. 4.

Electrically-Served Semet-Solvay Coke Plant at the Works of the Wigan Coal & Iron Company, Limited.* (22) Apr. 7.

Machine Tool Design.* J. T. Nicolson, M. Inst. C. E., and Dempster Smith. (12) Serial beginning Apr. 7.

500 B. H. P. Gas Driven Dynamo Engine.* (12) Apr. 7.

A New High Duty Shaper.* (17) Apr. 8.

Proportions of Machine Tool Parts.* Thos. R. Shaw. (47) Serial beginning Apr. 8.

Some Features in the Design of Oil Engines.* Edward Butler, M. I. M. E. (47) Serial beginning Apr. 8.

The Defects in Ingot-Iron Castings. K. Hermann Wedding. (From *Iron and Steel Magazine*.) (47) Apr. 8.

Sharp's Differential Flywheel.* (47) Apr. 8.

Multiple Steam Turbines.* A. Melencovich. (Paper read before the Inst. of Engrs. and Shipbuilders in Scotland.) (47) Apr. 8.

De Brouwer Charging and Discharging Machines at Lancaster.* (66) Apr. 11.

The New Gas-Works at Nuremberg.* (66) Apr. 11.

Gas Blowing Engines.* Tom Westgarth. (Abstract of Paper presented before the West of Scotland Iron and Steel Inst.) (20) Apr. 13.

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The Works of Messrs. Elliott Bros.* (73) Apr. 14.
Pressure Recorder for Gas Producers in Steel Works.* (22) Apr. 14.
Kennedy's Piston Inlet and Outlet Air-Valves for Blowing-Engines.* (11) Apr. 14.
Gas Producers in Ironworks.* Otto Wolff. (Paper read before the Assoc. of Ironmasters in South-West Germany.) (22) Apr. 14.
Gas Engines for Railway and Power Service.* (72) Apr. 15.
The New Works of the Ingersoll-Sergeant Drill Company.* (14) Serial beginning Apr. 15.
Crocker-Wheeler-Terry Turbo-Generating Set.* (27) Apr. 15.
Measuring Angular Velocity of Engines.* F. W. Springer. (27) Apr. 15.
Pattern Making.* R. Watson. (Paper read before the Rugby Eng. Soc.) (19) Apr. 15.
Power Production from Gaseous Fuel.* J. R. Bibbins. (Paper read before the Ohio Gas Light Assoc.) (24) Apr. 17; Abstract (14) Apr. 8.
More Light on the Tar Situation.* F. C. Slade. (24) Apr. 17.
The Testing and Valuation of Gas Coals. A. Edwards. (Paper read before the Yorkshire Junior Gas Assoc.) (66) Apr. 18.
Spencer's Vertical Hurdle Grid. (66) Apr. 18.
Gasholders and Tanks: Notes and Queries.* W. D. Child. (Paper read before the Eastern Counties Gas Mgrs. Assoc.) (66) Apr. 18.
Boosting and its Application to the Distribution of Gas. W. E. Dean. (Abstract of Paper read before the London and Southern District Junior Gas Assoc.) (66) Apr. 18.
The Proportions of Ingredients in Portland Concrete.* Richard T. Dana, Assoc. M. Am. Soc. C. E. (13) Apr. 20.
The Weber Suction Gas Producer.* (20) Apr. 20.
An Air Compressor with Mechanically Controlled Poppet Valves.* (13) Apr. 20; (16) Apr. 20; (17) Apr. 22; (41) May.
The Hughes Annealing Furnace.* (20) Apr. 20.
Feeding Modern Gas Motors. Emile Guarini. (From *The Gas Engine.*) (62) Apr. 20.
The Lentz Engine.* (12) Apr. 21.
The Electrical Driving of Rolling Mills.* (22) Apr. 21.
Application of Ball-Bearings to High-Speed Machinery.* W. Scott Lysle. (27) Apr. 22.
Steam Turbine Power Plant at a Poughkeepsie Shop.* (14) Apr. 22.
Effect of Oil on Strength of Boiler Furnaces.* D. B. Morison. (Paper read before the North-east Coast Inst. of Engrs. and Shipbuilders.) (47) Serial beginning Apr. 22.
Friction Clutches.* George A. F. Pover. (From *Technics.*) (19) Apr. 22.
Refractory Materials for Furnace Linings. E. Kilburn Scott. (Abstract of Paper read before the Faraday Soc.) (47) Apr. 22.
Improved Valve Gear for Gas Engines.* (47) Apr. 22.
Steam Engine Governors.* (47) Serial beginning Apr. 22.
Gas Producer for Bituminous Fuels.* (47) Apr. 22.
Report of Committee on Flow of Gas in Pipes. (Read before the Ohio Gas Light Assoc.) (24) Apr. 24.
The Methane-Hydrogen Gas Plant at Truro.* (66) Apr. 25.
Working with Deep Purifiers. C. H. Gifford. (Paper presented before the New England Assoc. of Gas Engrs.) (66) Apr. 25.
Notes on Concrete Block Manufacture. Fred. W. Haglock. (From *The National Builder.*) (13) Apr. 27.
Suction Gas Producers. Oskar Nagel. (19) Apr. 29.
Svea Caloric Engine.* G. Emil Hesse. (19) Apr. 29.
An Efficient Disk Transmission for Automobiles.* (46) Apr. 29.
Variable Speed Motors for Driving Machine Tools. (14) Apr. 29.
A Comparison of the Theoretical With the Actual Fuel Consumption in Cement Burning. Henry S. Spackman. (Paper read before the Assoc. of Amer. Portland Cement Mfrs.) (14) Apr. 29.
Belting. (25) May.
The Oerlikon Construction Shops in Switzerland.* L. Ramakers. (41) May.
The Hullett Automatic Ore Unloader.* Waldon Fawcett. (41) May.
European Gas Engines and Producer Plants.* Frank C. Perkins. (41) May.
The Franklin Four-Cylinder, Air-Cooled Motor.* (41) May.
Steam Engineering in Paper Mills. E. S. Farwell. (10) May.
Small Instruments of Measurement.* Joseph Horner. (10) May.
Grain Storage and Manipulation at the Quayside: with Special Reference to the Practice at British Ports.* Brysson Cunningham, Assoc. M. Inst. C. E. (10) May.
The Design and Operation of the Suction Gas Producer.* Rodolphe Mathot. (9) May.
Testing Coals and Lignites at the St. Louis World's Fair.* E. W. Parker. (9) May.
The Effects of Vacuum on Steam-Engine Economy.* R. M. Neilson. (9) May
The Ridgway Boring and Turning Mill.* (39) May.
Three-Foot Arm Combination Radial Drill.* (39) May.

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*Illustrated.

Mechanical—(Continued).

Installation and Care of Exhausters. E. D. Johnson. (Paper read before the Ohio Gas Light Assoc.) (24) May 1.
Long Distance Transmission of Gas. W. H. Hammon. (Paper read before the Ohio Gas Light Assoc.) (24) May 1.
Water Cooled Ports for Open Hearth Furnaces.* (20) May 4.
A Variable-Speed Gear: Giving All Speeds from Zero to a Maximum.* (From *Technics.*) (19) May 6.
Étude sur les Broyeurs.* Pierre Blanc. (37) Serial beginning Mar. 31.
Machines à Poser les Brides sur les Tuyaux Metalliques.* (33) Apr. 8.
Einige Bemerkungen über Verzahnungen.* E. Hagen-Torn. (52) Serial beginning Mar. 15.
Die Wolfsche Heissdampflokomobile in Tonindustriebetrieben.* Wiedemann. (Paper read before the Deutscher Verein für Ton-, Zement- und Kalkindustrie E. V.) (80) Mar. 30.
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Cast-Iron: Strength, Composition, Specifications.* W. J. Keep, M. Am. Soc. M. E. (75) No. 3, 1904.
The Effects of Strain and of Annealing in Aluminium, Antimony, Bismuth, Cadmium. Copper, Lead, Silver, Tin, and Zinc.* William Campbell. (75) No. 3, 1904.
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Notes on Testing Locomotives in England: Testing Plant on the Great Western Railway at Swindon. G. J. Churchward, M. I. Mech. E. (75) No. 3, 1904.
Measured Tests in Service: Instruments and Results Required at a Test. W. F. Pettigrew, M. I. Mech. E. (75) No. 3, 1904.
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Construction, Repairs and Subsequent Partial Destruction of the Arizona Canal Dam, Near Phœnix, Ariz.* H. F. Robinson. (13) Apr. 27.

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Vol. XXXI. MAY, 1905. No. 5.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PAPERS AND DISCUSSIONS.

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THE HYDRAULIC PLANT OF THE PUGET SOUND POWER COMPANY.

By Edwin H. Warner, M. Am. Soc. C. E.

To be Presented September 6th, 1905.

The hydraulic plant of the Puget Sound Power Company is located in Pierce County, Washington, and is the development of the Puyallup River for the purpose of supplying power to the Seattle Electric Company, the Tacoma Railway and Power Company, and the Seattle-Tacoma Interurban Railway, associated companies of the Stone and Webster Syndicate, of Boston, Mass.

The Puyallup River is torrential in its upper reaches, having its source in the glaciers on the western slope of Mt. Rainier.

Fifteen miles below the glaciers are located the dam and headworks, from which a flume, 10.2 miles long, brings the water to the reservoir. Thence it is carried by four penstocks, each 2 100 ft. long, to the power station on the river bank. A transmission line, 22¼ miles long, delivers the current at Bluffs, on the Seattle-Tacoma Interurban Railway, where it is distributed to the two cities.

The power station is 26 miles from Tacoma, with which city

Note.—These papers are issued before the date set for presentation and discussion. Correspondence is invited from those who cannot be present at the meeting, and may be sent by mail to the Secretary. Discussion, either oral or written, will be published in a subsequent number of *Proceedings*, and, when finally closed, the papers, with discussion in full, will be published in *Transactions*.

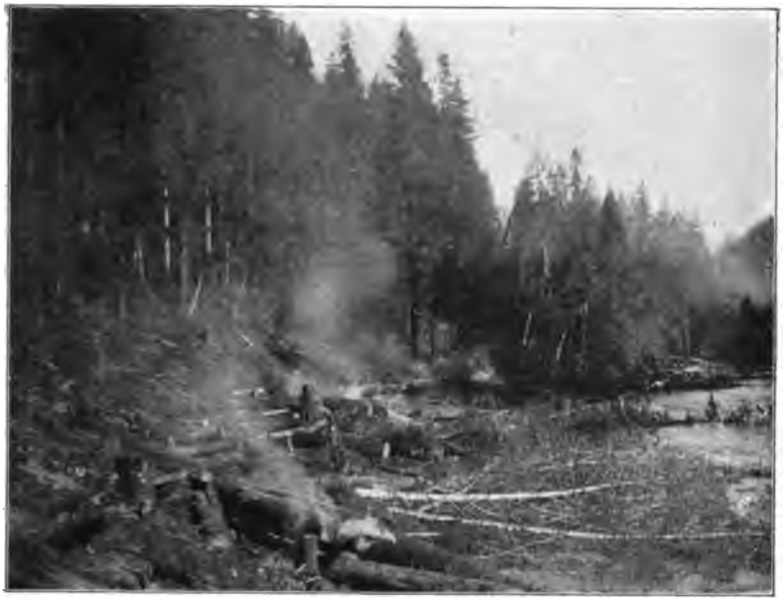


FIG. 1.—CLEARING AT SITE OF HEADWORKS.

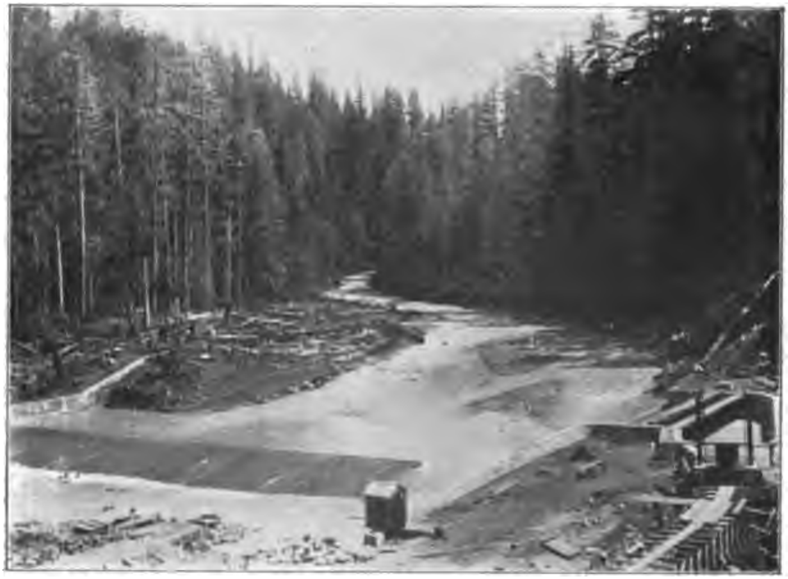
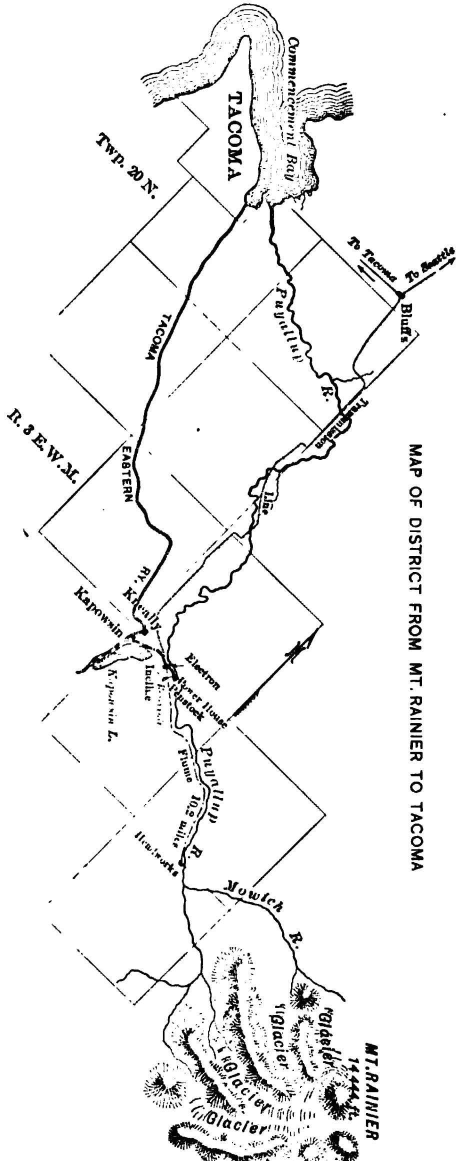


FIG. 2.—HEADWORKS.



MAP OF DISTRICT FROM MT. RAINIER TO TACOMA

FIG. 1.

there is communication over the Tacoma Eastern Railway, a logging road doing business in the vicinity.

The work, preliminary to the construction of the plant, consisted of the improvement of 6 miles of county road, from Kneally; the building of 15 miles of wagon road past the reservoir site to the head-works; the construction of a cable incline to the reservoir site, rising 930 ft. in 4 100 ft.; the grading and laying of 3 miles of track to the commissary headquarters and saw-mill; the erection of one saw-mill near the head of the cable incline, and one within a mile of the head-works; the building of a machine shop, and the installation of a lighting plant.

In May, 1903, the railway company built a spur from Kapowsin Lake to the foot of the cable incline; this cut out the wagon haul from Kneally, and standard loads were hauled to Midway, at the foot of the steep grade on the cable incline, where they were reloaded on small cars.

At the foot of the incline, the power company built a depot, put in 1 500 ft. of storage track, and extended the railway spur 7 000 ft. to the site of the power station.

DAM AND HEAD-WORKS.

Dam.—The dam is a low timber-crib structure, triangular in section, and founded on gravel. It is 200 ft. long on the crest line, 60 ft. wide at the base, with an apron extending 20 ft. down stream. The crest line is 5 ft. above the bed of the river, and at the west end is dropped 1 ft., giving a spillway 30 ft. long and 12 ft. wide.

All the crib tiembers are 12 by 12-in., and are fastened at the intersections with ¾-in. drift-bolts. The longitudinal timbers are built into the concrete abutments at each end.

The east half of the site was sheet-piled, and excavated to a depth of 4 ft., and foundation sills were set. Along the upper toe, under the center, and at the lower toe of the dam, 3 by 12-in. double-lap sheet-piling was driven to a further depth of 6 ft. In places where the driving was unsatisfactory, excavation was made, the piling was set and the excavation filled to the top of the foundation sills with concrete or clay puddle. By the time the east end was finished, work on the intake was so far advanced that the river was

PLATE XXXVIII.
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HYDRAULIC POWER PLANT.

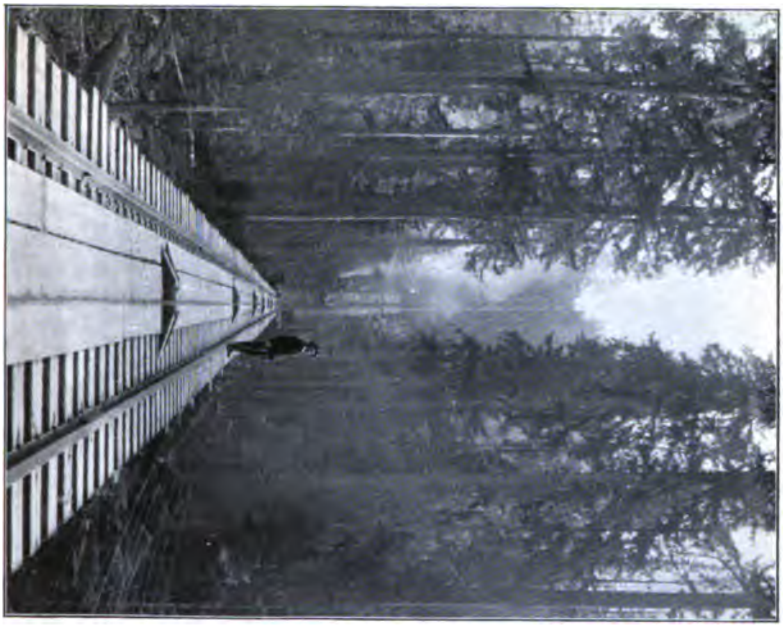

FIG. 1.—CABLE INCLINE, FROM MIDWAY UP.

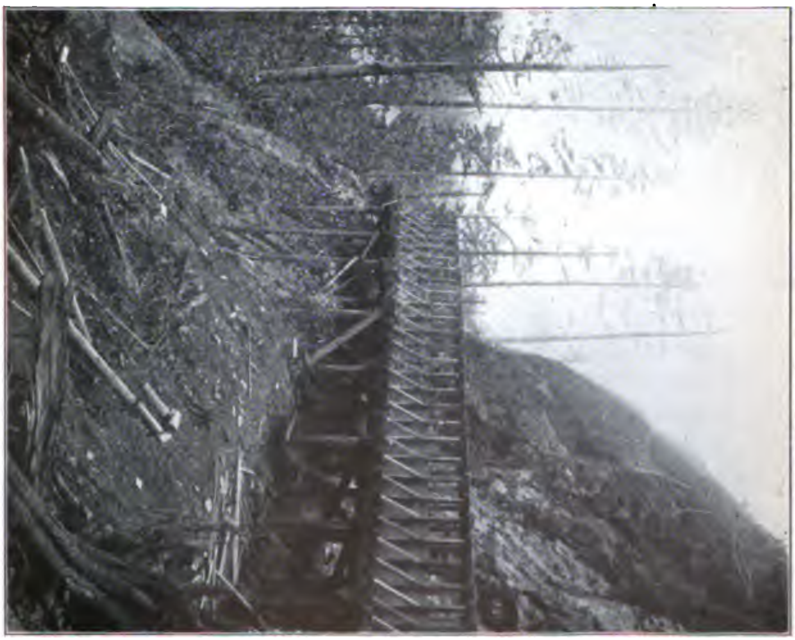

FIG. 2.—FLUME AT ROCKY POINT.

PLAN OF HEADWORKS

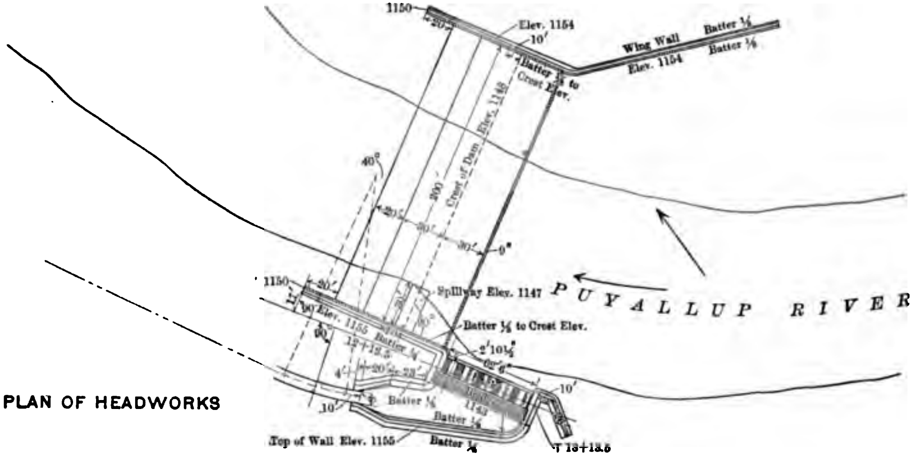

FIG. 2.

diverted, the west end of the dam site was similarly treated, and the dam completed. The upper face of the dam is sheathed with a triple lap of 3 by 12-in. plank spiked to the purlins. The lower face and apron are 8 by 12-in. timbers drift-bolted to the purlins with ⅝-in. round iron. The crest of the dam has a protection of ¼ by 48-in. boiler plate, and the crib pockets are filled with rock and boulders. A lighting plant for night work was installed, and a 10-in. centrifugal pump was used to keep down the water inside the coffer-dam.

Abutments.—The east abutment is carried up stream 20 ft. from the toe of the dam, and then flares to the east for 140 ft. to prevent high water from passing through a low swale and thus around the structure. The east abutment is returned on itself and continued as the east wall of the intake.

Intake.—The intake has an entrance width of 60 ft., which narrows to 8 ft. at its connection with the flume. Flash-boards at the entrance permit of such regulation that surface water only may be taken, and the passage of sand and gravel into the flume is prevented. Immediately back of the flash-boards are set ¼ by 3½-in. iron rack-bars, spaced 2 in. apart. In the throat of the intake there

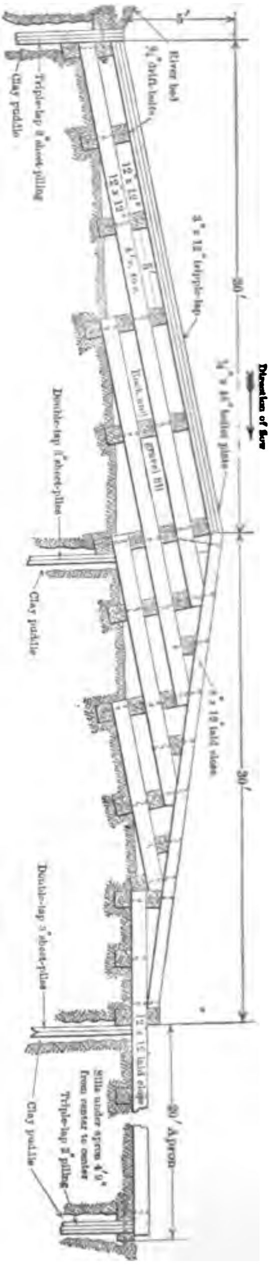

FIG. 3.

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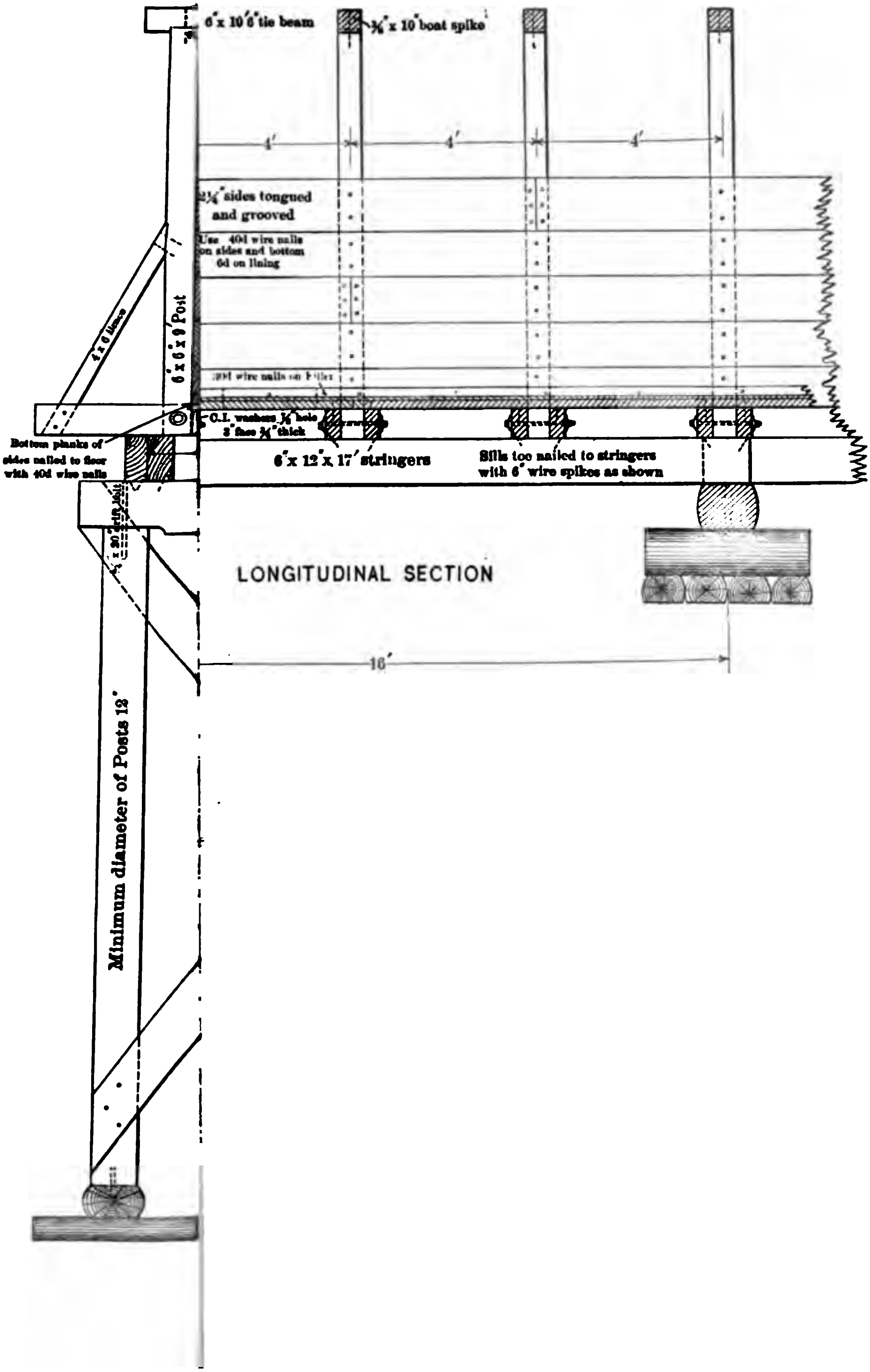
6" x 10' 6" tie beam
⅜" x 10" boat spike
4'
4'
4'
2¼" sides tongued and grooved
Use 40d wire nails on sides and bottom 6d on lining
20d wire nails on Filler
4 x 6 Brace
6" x 6" x 9' Post
C.I. washers ⅞" hole 3" face ¾" thick
Bottom planks of sides nailed to floor with 40d wire nails
6" x 12" x 17' stringers
Sills toe nailed to stringers with 6" wire spikes as shown
¾" x 20" drift bolt
16'
Minimum diameter of Posts 12"

LONGITUDINAL SECTION

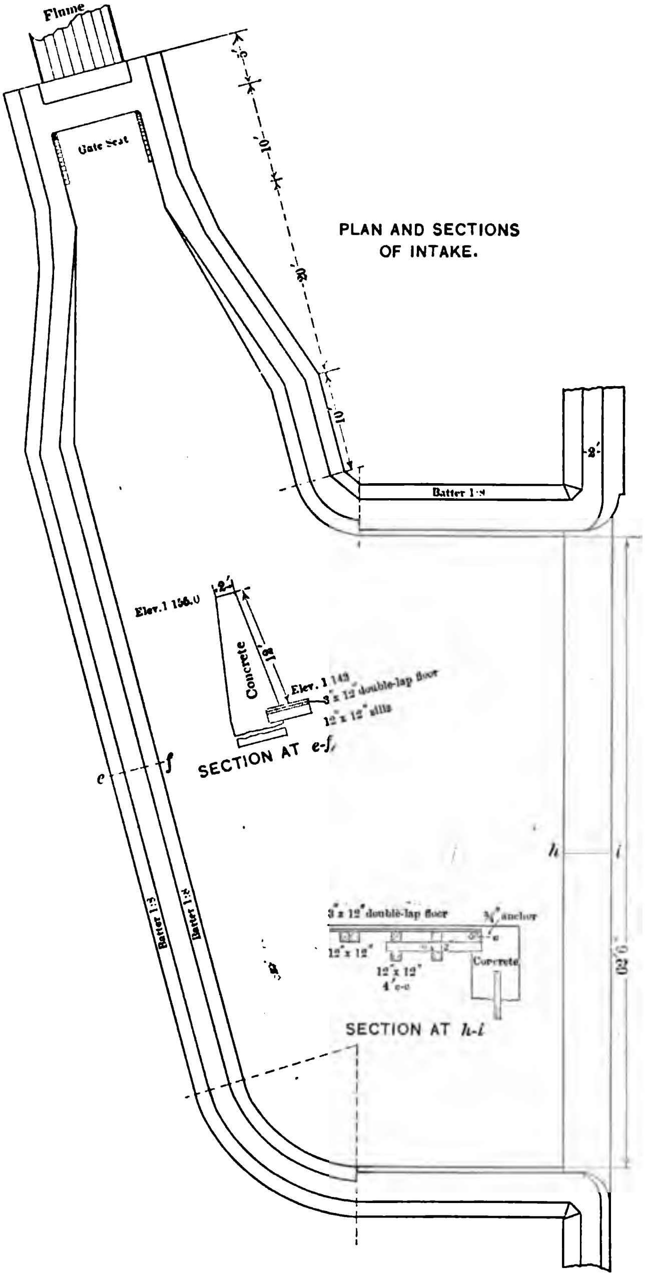
PLAN AND SECTIONS OF INTAKE.

Fig. 4.

is a radial gate with a tank counterbalance. The abutments and intake walls are of concrete, and the intake floor is a double lap of 3 by 12-in. planks spiked to 12 by 12-in. sills, the ends of which are built into the walls. A 3 by 24-in. box-drain relieves the floor from any upward pressure.

All concrete was hand-mixed in the proportions of 1 part of cement, 3 parts of sand and 6 parts of gravel. It was deposited from wheel-barrows, and tamped. The sand and gravel were found on the site. The gravel was washed before using, and a portion of the sand was similarly treated. The cement used was Alsen's German Portland, giving an average of 450 lb. for 7-day tests. A series of tests on 1 to 3 mortar gave an average of 160.5 lb. for the same time. Tests made immediately after breaking gave 12.5% moisture for the highest test briquettes; departure both ways from this percentage accompanied those below the average.

In this portion of the work, 1 426 cu. yd. of concrete, 500 000 ft., B. M., of lumber and 13 tons of iron were used. The contract for the head-works was let to Messrs. Porter Brothers, of Spokane, Wash., for a lump sum of $45 000, with unit prices, to cover any increase or decrease of work, as follows: Concrete, $10; wet excavation, $8; dry excavation, $1, per cubic yard.

FLUME.

The precipitous side-hill, upon which the flume line is located, made a trestle substructure necessary for practically its whole length. The calculated velocity in the flume was such that only rock would resist erosion, while the high angle of the hillside rendered any increase in flume section impossible, except at a prohibitive first cost and charge for maintenance.

The substructure consists of a sill laid on 6 by 12-in. mud-sills, 3 ft. 6 in. long, three plumb posts, at 5 ft. 6 in. centers, with dowels and pins to the sills, and caps, 13 ft. long, drift-bolted to the heads of the posts with ¾-in. round iron. On the caps, six 6 by 12-in. stringers, 17 ft. long, are laid and drift-bolted. With the exception of the stringers, round timber, cut near the site, was used. The bents were spaced at 16-ft. centers, and, where necessary, 3 by 12-in. sway-bracing was used. The height of the substructure ranges from

PLATE XL.
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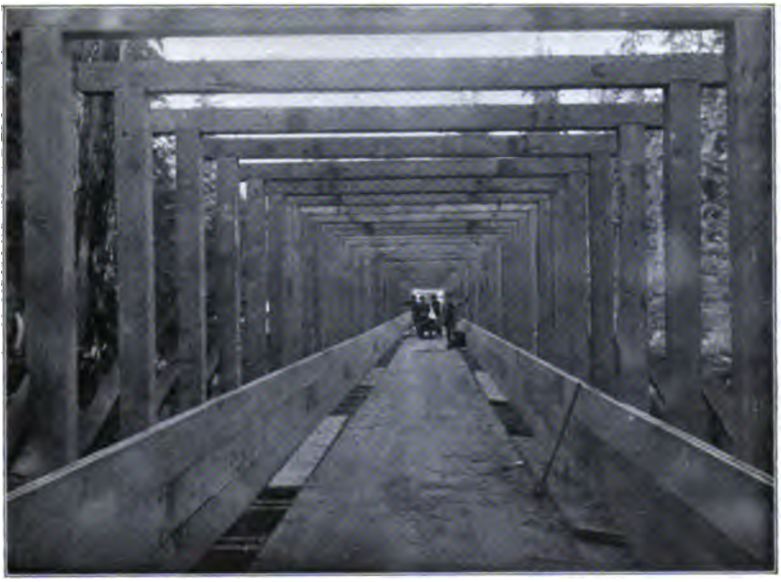

FIG. 1.—FLUME FRAME, WITH PART OF FLOOR AND SIDING IN PLACE.

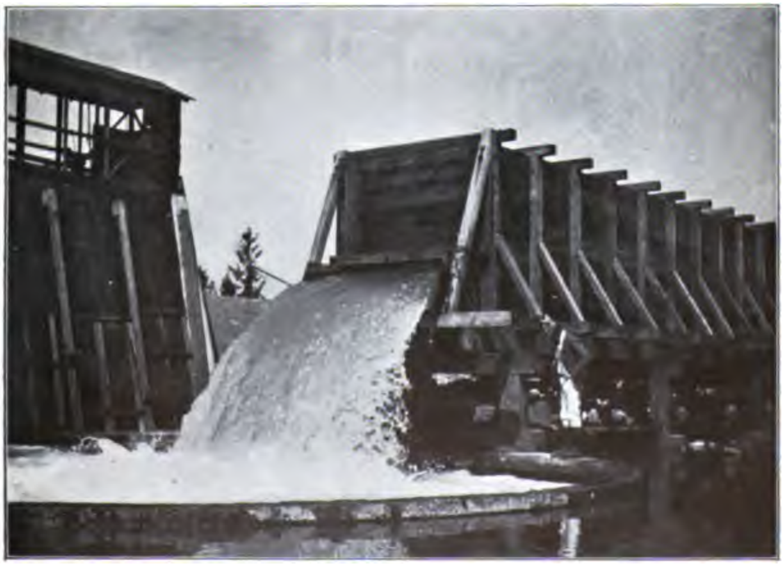

FIG. 2.—FOREBAY, WITH FLUME DISCHARGING INTO POOL.

6 to 80 ft., reaching the later figure, however, only in two gulch crossings.

After clearing the line, construction was begun at four different points, and, as fast as completed from the reservoir end, a broad-gauge track was laid with 35-lb. rails, and the distribution of the flume material was begun. Eight miles of track were thus laid and used, and material for the remaining 2.2 miles was cut at the upper saw-mill and delivered by wagon.

Approximately, 8 000 000 ft., B. M., of lumber and 60 tons of iron and nails were used in building the substructure. All clearing, excavation for the sills, the trestle bents to hardpan, and the erection of the substructure, including laying the stringers, ties and track, were done by the company's force.

The flume alignment, following closely a grade contour, shows of necessity a large amount of curvature. This aggregates 10 280°, a trifle more than 1 000° per mile, the maximum curve being 70 degrees. This curvature, while not remarkable in a flume, prohibited the use of standard equipment on the track, and the company built, at its shop at the reservoir site, forty small four-wheel flat cars, 7 by 16 ft. over all. The conditions precluded any superelevation of the rail, and a loose box, giving large end play to the axle, was adopted. This served the purpose admirably, and speeds up to 12 miles an hour were attained without derailment. Three 16-ton four-wheel engines were used for work on the flume and in the yard.

A number of the cars were fitted up with strong backs, and were used on the steep portion of the cable incline from Midway up.

Superstructure.—To the stringers of the substructure are toe-nailed two 4 by 8-in. sills, 15 ft. long, and spaced 6 in. apart. A 6 by 6-in. post, 9 ft. long, is dropped between and held by a ¾-in. machine-bolt, 17 in. long. A 4 by 6-in. brace, 6 ft. long, is spiked to the sills and posts, and these, with a 6 by 6-in. tie-beam, 10 ft. 6 in. long, gained and spiked to the heads of the posts, form the flume framing, which is spaced at 4-ft. centers. The floor is of 2 by 12-in. plank with a 1 by 12-in. lining, and the sides are of 2¼-in. tongued and grooved stuff. In the corners there is a 2¾ by 2¾-in. fillet, and between the lining and the floor plank there is a 6-in. strip of tarred paper, turned up and held in place against the side by the fillet. The floor planks are laid straight, in lengths of from 16 to

32 ft., and on curves the segments are cut to a driving fit. The tongued and grooved siding, in similar lengths, was bent to place, held by clamps and driven down without difficulty.

With a view to its use independent of the reservoir, the flume is extended to the fore-bay, where it passes through the reservoir embankment. Two rows of sheet-piling, 20 ft. apart, were set in 4-ft. trenches which were filled with concrete. The sheet-piling was spiked to the flume, which was carried above the high-water line and extends 6 ft. into the embankment on each side. The trench was carefully puddled, and no seepage has occurred.

Within the reservoir, plank was laid on the trestle-sills, the flume was tied down with rods, and the plank loaded with boulders.

Five mud-boxes, at intervals along the flume, intercept any solid matter which passes the intake. The gates are of plank, slide in wooden grooves, and are raised with a bar for flushing.

Seven spillways, with needle-gates below, permit the flow to be diverted when necessary. They are provided with an apron, and, where required, with a small flume to carry the water clear of the substructure.

There is one automatic regulating spillway, 1 800 ft. from the reservoir. It consists of an apron, 132 ft. long, the lip of which is level with the high-water line in the reservoir. A 4 by 6-ft. flume on a heavy grade carries the water beyond an adjoining rock bluff.

The flume is 8 ft. wide, in the clear. For the present installation of 20 000 h-p. the sides are built up 4 ft. 6 in., and will be raised to the full height of the framing when the plant is extended. The last 3 000 ft. of the flume is sided to the full height in order to make the regulating spillway operative. A gate of 3 by 3-in. needles, near the end of the flume, regulates the flow to the fore-bay. With the reservoir full, the gate will be retained as a safety device to prevent a back flow in case of a break in the flume close at hand. The grade of the flume is 0.00136, and, by Kutter's formula, gives a discharge of 280 cu. ft. per second, using 0.0105 as the value for "*n*," and with a depth of 4 ft.

As fast as the distribution of material by train was completed, at the end of the track, the rails were taken up and placed on the substructure caps, and work on the flume proper was begun. When completed, the track was relaid on top of the flume.

PLATE XLI,
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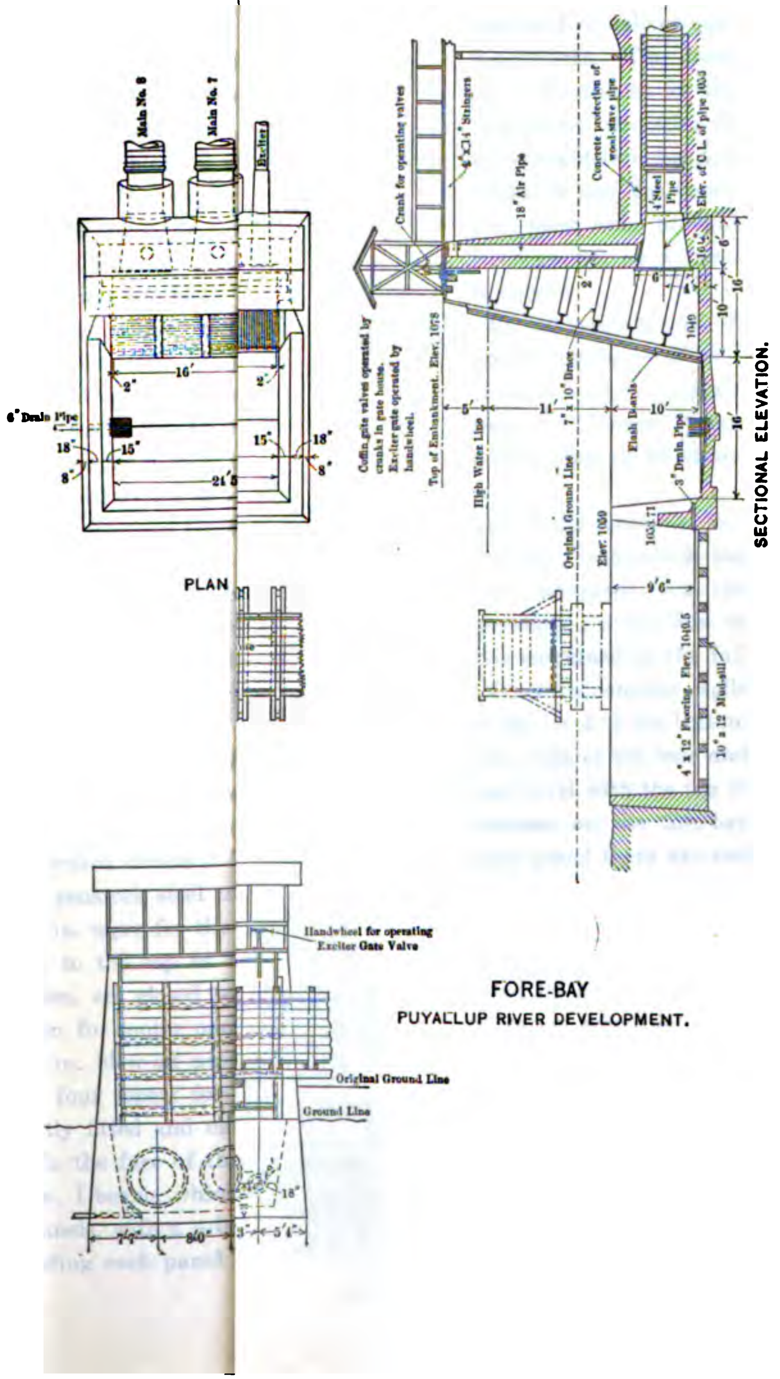
MAY, 1905.
WARNER ON
HYDRAULIC POWER PLANT.



FORE-BAY
PUYALLUP RIVER DEVELOPMENT.

Hand-cars are now used for patrol purposes and to deliver supplies for the use of the watchman at the head-works. The flume tie-beams are spaced at 4-ft. centers, and, as a derailment at any point would be serious, a safety device was originated, consisting of a 2 by 4-in. piece, 6 ft. long, suspended from wrought-iron hangers in front of the wheels and 1 in. above the track. When the wheels leave the track the car skids on this 2 by 4-in. piece until brought to rest. It works satisfactorily, and the patrolmen get up a speed of 10 miles per hour, seemingly confident of results.

In the superstructure, 6 000 000 ft., B. M., of lumber, and 75 tons of iron and nails were used. The company furnished all material, which cost $12 per thousand feet for lumber, and 4 cents per pound for iron. The contract for erection was let to Messrs. Porter Brothers, for a lump sum of $40 000, with a unit price of $8.00 per thousand feet for additional material.

Fore-bay and Gate-wall.—At the north end of the reservoir, and 20 ft. within the toe line, is located the fore-bay, into which the flume discharges. The 30-ft. horse-shoe pool is separated from the fore-bay proper by a wall 5 ft. high, which prevents a direct flow to the penstocks, and allows the escape of the air entrained in the fall from the flume. The fore-bay is 32 by 80 ft., with concrete walls and floor; three walls are built 10 ft. high, to the level of the bottom of the reservoir; the fourth is a gate-wall, 6 ft. wide at the base and 3 ft. at the top. It is carried 19 ft. higher and level with the top of the reservoir embankment; it has five buttresses on the fore-bay side which divide it into four panels. In each panel there are two 6-ft. penstock steel tapers; the east end panel contains, in addition, a 24-in. taper for the exciter pipe. Each taper has an air inlet running to the top of the gate-wall. The four now in use, and the exciter, are closed with Coffin valves, operated by hand, with provision for motor operation from the power station when desirable. A 6-in. blow-off pipe frees the fore-bay of water when necessary. The four tapers for future use are closed with wooden bulkheads, tightly fitted and caulked with oakum.

In the face of the buttresses are embedded horizontally six 7 to 12-in. I-beams which support the rack-bars; two sets of two 8-in. channels, with a 4-in. wooden filler, are bolted to the I-beams, subdividing each panel into three spaces of approximately 5 ft. each;

the top of the channels and a wooden cover piece form a groove in which the flash-boards slide, thus isolating for examination any two pipes from the fore-bay without emptying the latter or interrupting the operation of the plant.

The rack-bars are of wrought iron, ¼ by 3 in. in section, held together with ¾-in. rods, and packed with ⅞-in. cast-iron separators. This spacing gives a velocity of 0.87 ft. through the racks, with the water at the top of the fore-bay wall. This is reduced to 0.39 ft. with the water at the high-water line in the reservoir. In front of the exciter gate the spacing is reduced to ½ in., and an additional set of racks, similarly spaced, isolates the exciter from the other tapers within the panel.

The source of supply being high up in the mountains, very little foreign matter is brought down the flume, and no clogging of the racks has occurred.

The concrete is a mixture of 1 part of cement, 3 parts of sand and 6 parts of broken stone. The cement used was Alsen's German Portland. The sand, from a pit on the power-house spur, is a very clean, coarse, sharp, river sand. The broken stone is a basic trap, microcrystalline in structure, with very sharp edges, and was quarried and crushed at the power-house site, loaded on cars, and hauled up the incline. The concrete, of which 586 cu. yd. were used, was mixed very wet, in a double-cone, continuous mixer. The contract for this work was let to Messrs. Bihler and Rydstrom, of Tacoma, Wash., for a lump sum of $7 425, including excavation below the level of the reservoir, with unit prices of $8.50 per cubic yard for concrete, and $1.75 per cubic yard for excavation.

Reservoir.—The site selected for the reservoir is on a bench sloping at the rate of 4.5 in 100. This prescribed a long narrow form, which will become more pronounced when extended for future requirements. The first operation was to cut the large cedar and fir timber; the stumps were then blasted out and removed.

The material excavated was a highly indurated boulder clay, requiring powder to loosen it for handling with a steam shovel; this was overlaid, to a depth of from 2 to 4 ft., with sand and gravel and loam. As it was impracticable to save and mix the sand and gravel with the clay in any definite proportion for use in the embankment, all loose material was stripped off and wasted. Excavation to a face

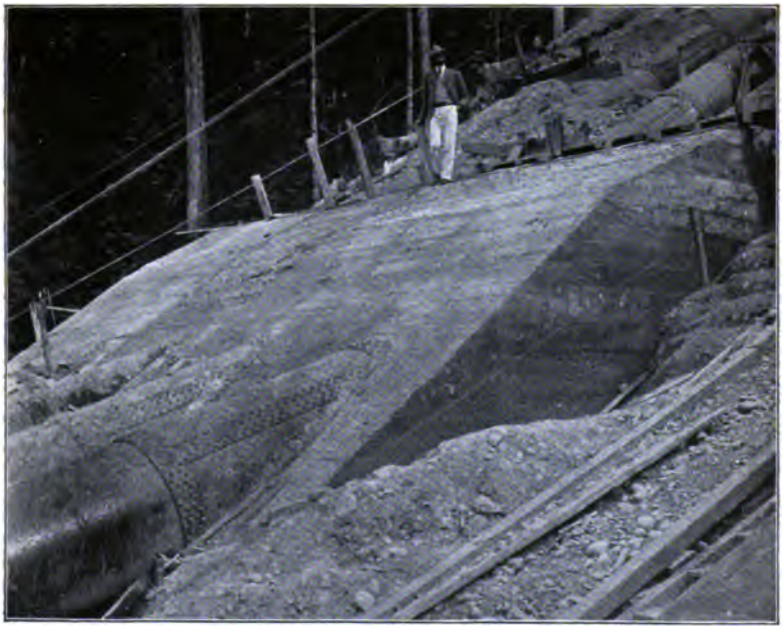


FIG. 1.—MAIN ANCHORAGE.

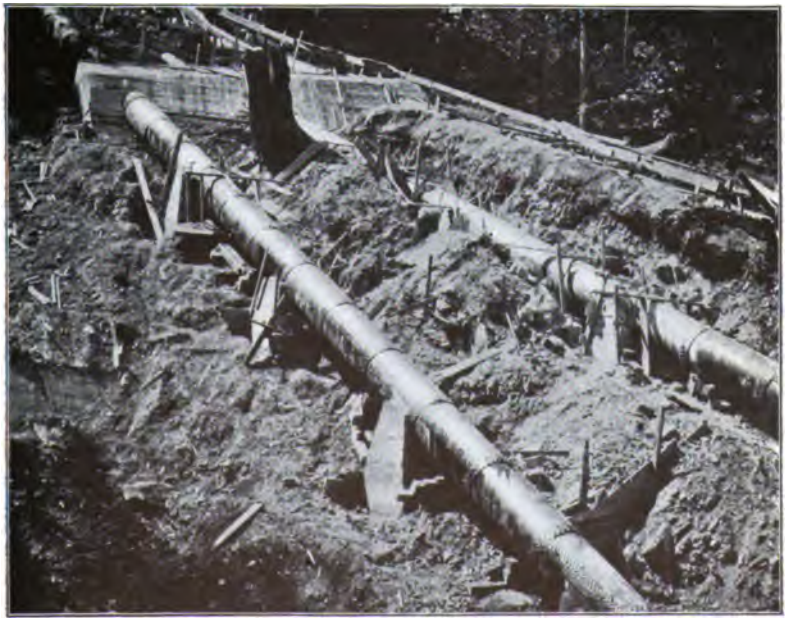
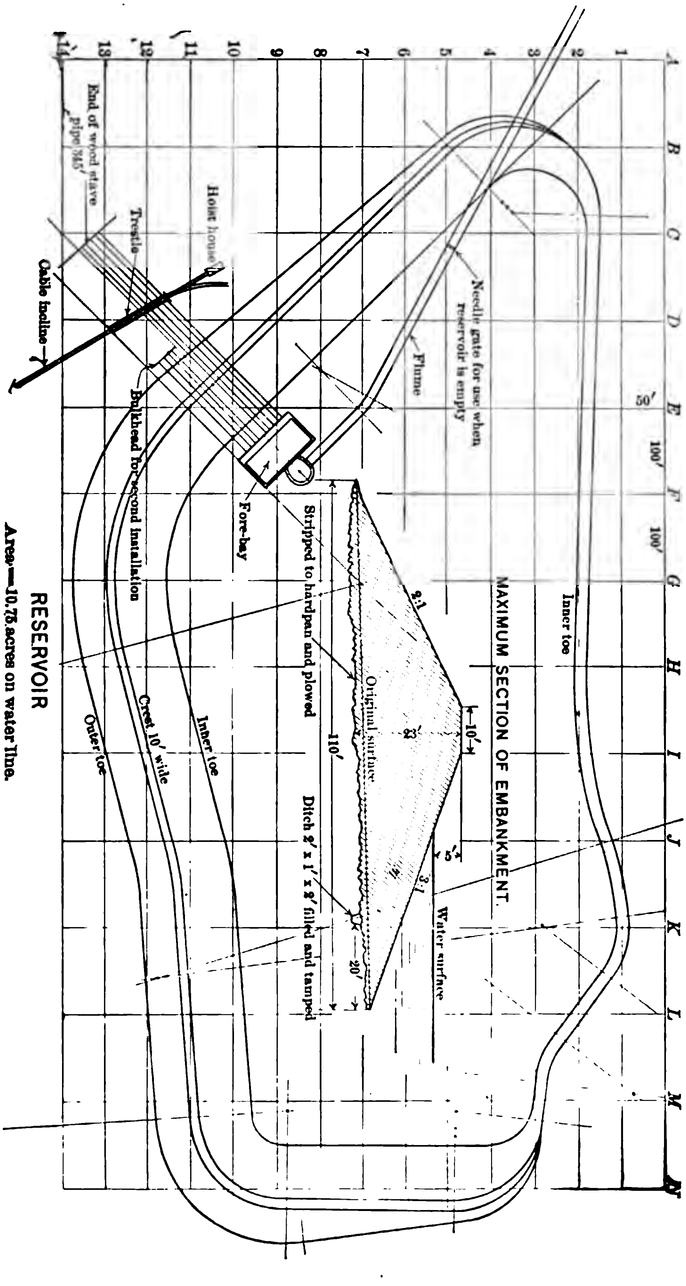


FIG. 2.—PIPE LINES, WITH AUXILIARY ANCHORAGE.


A
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1
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3
4
5
6
7
8
9
10
11
12
13
14
50′
100′
100′
Inner toe
Needle gate for use when reservoir is empty
Flume
Hoist house
Trestle
End of wood stave pipe 345′
Cable incline
Bulkhead for second installation
Fore-bay
MAXIMUM SECTION OF EMBANKMENT.
2:1
10′
23′
Original surface
Stripped to hardpan and plowed
110′
5′
3:1
Water surface
Ditch 2′ x 1′ x 2′ filled and tamped
20′
Inner toe
Crest 10′ wide
Outer toe

RESERVOIR

Area=10.75 acres on water line.

Fig. 5.

of 4 ft. was made by hand and run out on small cars by team; the remainder was done by steam shovel and train. The embankment site was stripped and plowed, and a ditch, 20 ft. inside the inner toe line, was excavated. A trestle at the proposed height of the embankment was built, from which the material was dumped. A steel scraper of special form, hauled by two hoisting engines from toe to toe of the embankment, was used to spread the material. The wet condition of the clay, due to the continuous rains in this section, and its treatment by scraper made an embankment which has proved practically impervious to water. An attempt was made to roll the material in layers, but as it resulted in the disappearance of the roller, the puddling process was substituted. Care was taken to isolate all boulders, which form a considerable percentage of the mass and add materially to its stability. The excavation amounted to 132 166 cu. yd., of which 105 131 cu. yd. were built into the embankment.

For 4 weeks water was admitted to the reservoir at the rate of 0.75 ft. per week, and held at the 3-ft. level for one week; the 7-ft. level was reached in 3 weeks more, and on July 15th reached the 8-ft. mark. Continuous inspection has failed to reveal any leak, while the seepage is insignificant in amount, and does not increase with the increase in depth. The maximum section is 20 ft. high, with a base of 113 ft. and a top 10 ft. wide, and inner and outer slopes of 3 : 1 and 2 : 1, respectively. The embankment was trimmed by hand to the true slope, and the outer slope, top, and inner slope to the water line were sown with clover. The area is 10.75 acres at the water line, and no destructive wave action is apprehended, as the prevailing winds are from the south, and the flume extension and gate-wall reduce the exposed north line to less than 100 ft.

The reservoir gives 6½ hours' storage with 14 ft. depth. This is based on the production of 20 000 h-p., with an effective head of 850 ft.; 276 cu. ft. of water per second; 75% wheel efficiency, and a power factor of 100% for the time given. The contract for the reservoir was let to Messrs. Porter Brothers, for a lump sum of $81 595.50, with a unit price of 71¼ cents per cubic yard for borrowed material.

The excavation of suitable material exceeded the neat section of embankment by 8 000 cu. yd., which were built into the embankment.

PLATE XLIII.
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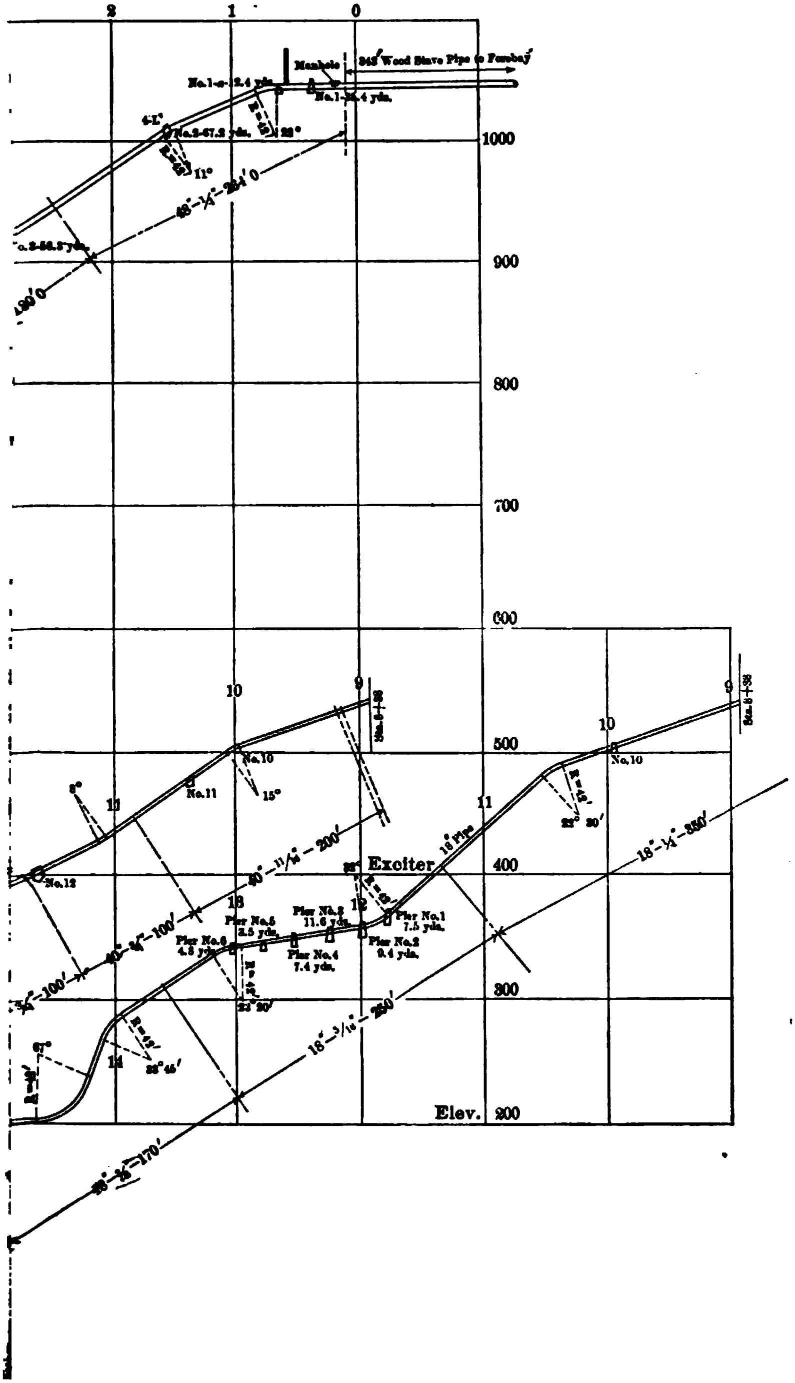
MAY, 1905.
WARNER ON
HYDRAULIC POWER PLANT.



Wood-Stave Penstocks.—The wood-stave penstocks consist of eight 4-ft. mains and one 18-in. main. Four of these are carried 175 ft. through the embankment, and bulkheaded. They will be reserved until the second installation is made.

The others, 345 ft. in length, connect with the steel pipe. They are built-up wood pipes. The staves were cut from 2 by 6-in. clear lumber, dressed to radial lines, with a circular curve inside and out, and have oak tongues in the butt joints. Round-iron bands, $\frac{5}{8}$ in. in diameter, coated with asphalt composition, hold the staves in place. The bands are spaced at 8-in. centers, except at the butt joints, where the space is reduced to 4 in. Two concrete cut-off walls within the embankment enclose the pipe and extend 2 ft. above. This work was let to the National Wood Pipe Company, of San Francisco, Cal., at $2.96 and $41.47 per foot, for 18 and 48-in. pipe, respectively, the power company handling the material from the foot of the incline to the site of the work.

The wood pipe slips into a double-angle steel bellmouth riveted to the taper at the gate-wall, and is caulked with lead. A similar joint connects it to the steel portion of the penstock. The pipe through the embankment is protected by concrete, reinforced over the pipe with expanded metal. Bids were invited for this concrete protection, but the acceptance of the lowest, $7 200, and 30 days' time for completion, was not considered wise, and a company's force was organized. The work was completed in 11 days at a cost of $4 640.

Steel Penstocks.—The main penstocks are compound pipes, 1 730 ft. long, reducing at intervals from 4 ft. to 3 ft. in diameter, and of varying thickness, as shown in Table 1. The exciter pipe maintains its diameter of 18 in. throughout its length. A manhole and an air inlet are provided in each pipe near the wood-pipe connection.

The pipe was delivered at the power station and at the head of the cable incline, and then put in a place by means of a small tramway and hoist. The pipe was laid, holes were reamed and the joints riveted; the seams were caulked inside and out, and painted. Air tools were used for the entire work, with the exception of a small amount of hand-caulking. Anchor angles, 6 by 6 in., were riveted on, enclosing 220° of pipe; four angles were used on each pipe in the main anchorages, and one in the auxiliaries. For purposes of

TABLE 1.—MAKE-UP OF STEEL PIPE.

Diameter, in inches.	Length, in feet.	Thickness.	Diameter of rivets.	Pitch of rivets.	BUTT STRAPS.		Remarks.
					On straight seams.	On circumferential seams.	
48	264	¼ in.	⅝ in.	Straight seams, 2¼ in. Circumferential seams, 1 9/16 in.			Double-riveted lap. Single-riveted lap.
48	180	5/16 "	⅝ "	Straight seams, 2¼ in. Circumferential seams, 1 9/16 in.			Double-riveted lap. Single-riveted lap.
....	5	......	......	....	....	....	Reducer, 48 to 45 in.
45	195	⅜ in.	⅝ in.	3 in.	9/32 x 7 in.	⅜ x 7 in.	Double-riveted butt straps.
....	5	......	......	....	....	....	Reducer, 45 to 42 in.
42	195	7/16 in.	⅝ in.	3 in.	5/16 x 7 in.	7/16 x 7 in.	Double-riveted butt straps.
42	200	9/16 "	¾ "	3½ "	7/16 x 8 "	9/16 x 8 "	Double-riveted butt straps.
....	5	......	......	....	....	....	Reducer, 42 to 40 in.
40	195	11/16 in.	¾ in.	3½ in.	½ x 9 in.	11/16 x 9 in.	Double-riveted butt straps.
40	100	¾ "	13/16 "	3½ "	9/16 x 12 "	¾ x 10 "	Double-riveted butt straps.
40	100	¾ "	13/16 "	3½ "	9/16 x 12 "	¾ x 10 "	Triple-riveted butt straps.
....	5	......	......	....	....	....	Reducer, 40 to 36 in.
36	273	¾ in.	13/16 in.	3½ in.	9/16 x 12 in.	¾ x 10 in.	Triple-riveted butt straps.
18	690	No. 10	⅜ "	1¼ "	Exciter pipe. Double-riveted lap on straight seams. Single-riveted lap on circumferential seams. Joints, flange-riveted.		
18	200	No. 8	7/16 "	1½ "			
18	100	3/16 "	½ "	1½ "			
18	350	¼ "	9/16 "	2 "			
18	250	5/16 "	11/16 "	2¼ "			
18	170	⅜ "	¾ "	3 "			

calculation, a rivet stress of 42 000 lb., ultimate tensile stress, with a factor of safety of 5, was used.

The use of inside riveters, and caulking the seams inside, resulted so satisfactorily that, when tested under full head, only one pipe required touching up, and that was done by one man in less than 3 hours. On completion, the pipes were covered to within 18 in. of the top, scarcity of material preventing the complete covering. This partial exposure is not a source of anxiety in this climate, where the mean annual temperature is high, and the daily variation not considerable. The temperature of the glacial water is low, averaging 50.3° at the fore-bay, and reaching 52.1° in the tail-races at the power-house; the extremes are 44 and 55° at the fore-bay, and 47 and 56° at the power-house. The Risdon Iron and Locomotive Works, of San Francisco, Cal., took the contract for a lump sum of $140 000 for the material and the erection of the pipe complete.

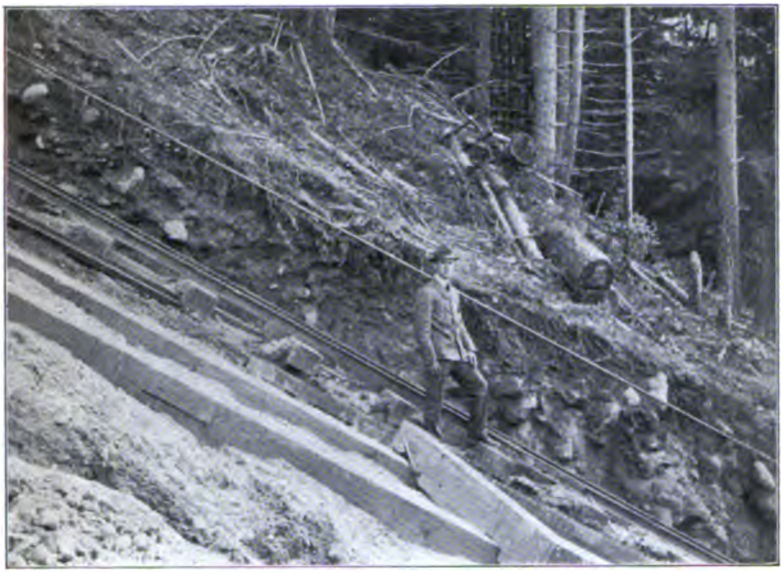


FIG. 1.—CABLE INCLINE; 65.6% GRADE AT THIS POINT.

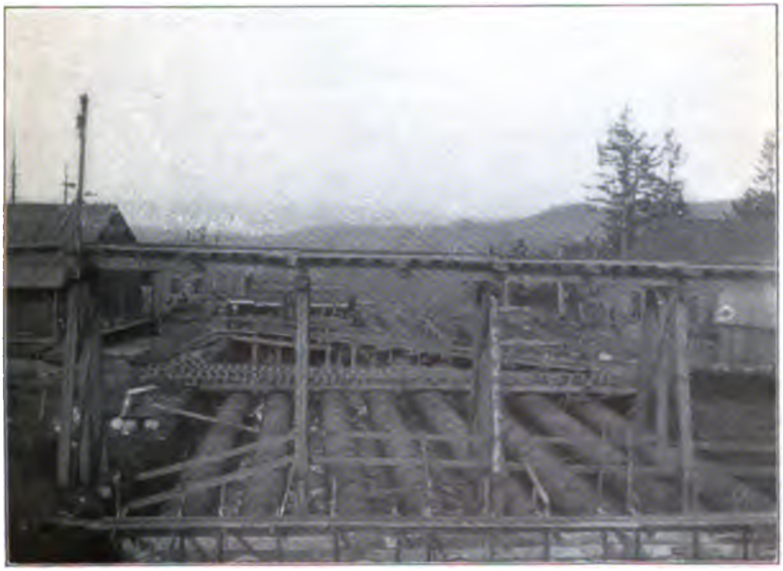


FIG. 2.—WOOD PIPE, WITH TRESTLE IN FOREGROUND FROM WHICH EXCAVATED MATERIAL FOR EMBANKMENT WAS DUMPED.

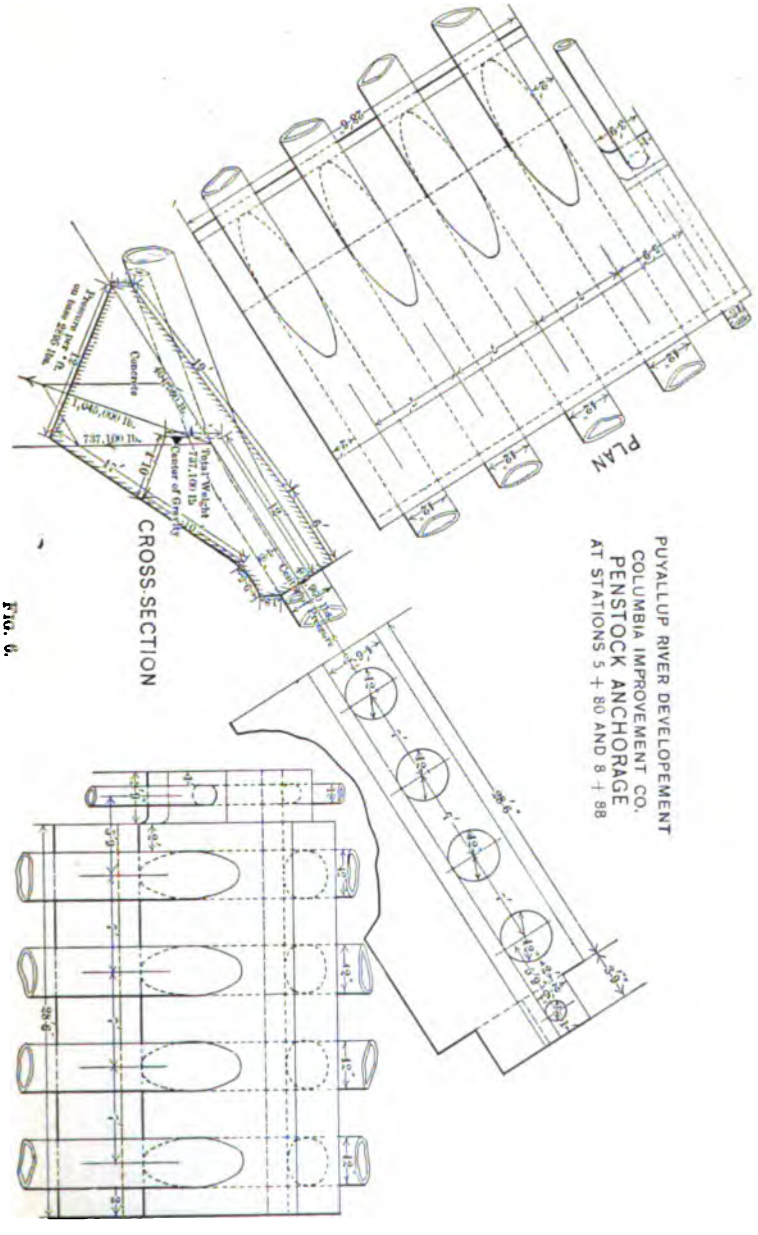

PUYALLUP RIVER DEVELOPEMENT
COLUMBIA IMPROVEMENT CO.
PENSTOCK ANCHORAGE
AT STATIONS 5 + 80 AND 8 + 88
PLAN
CROSS-SECTION
Concrete
Pressure per sq. ft. on base 2800 lb.
1,045,000 lb.
737,100 lb.
Total Weight 737,100 lb.
Center of Gravity
28'-6"
42"
12"
7'
3'-9"

FIG. 6.

The work was done under difficult conditions of weather, steep slopes and lack of space at the power-house and reservoir ends. The thorough nature of the work, under these adverse conditions, is shown in the very satisfactory test just referred to.

Anchorages.—Concrete anchorages are built around the pipes at intervals of 125 ft. The main anchorages, alone, are designed to resist without movement any stresses which may be imposed; the auxiliary anchorages are similarly designed to resist these stresses independent of the main anchorages. In designing these anchorages, frictionless surfaces of pipe and ground were assumed. The concrete is a mixture of 1 part of cement, 3 parts of sand, and 6 parts of gravel. The gravel was washed, and the concrete was mixed by hand. The cement and sand were of the same quality as used in the fore-bay work. The concrete amounts to 1 300 cu. yd.,

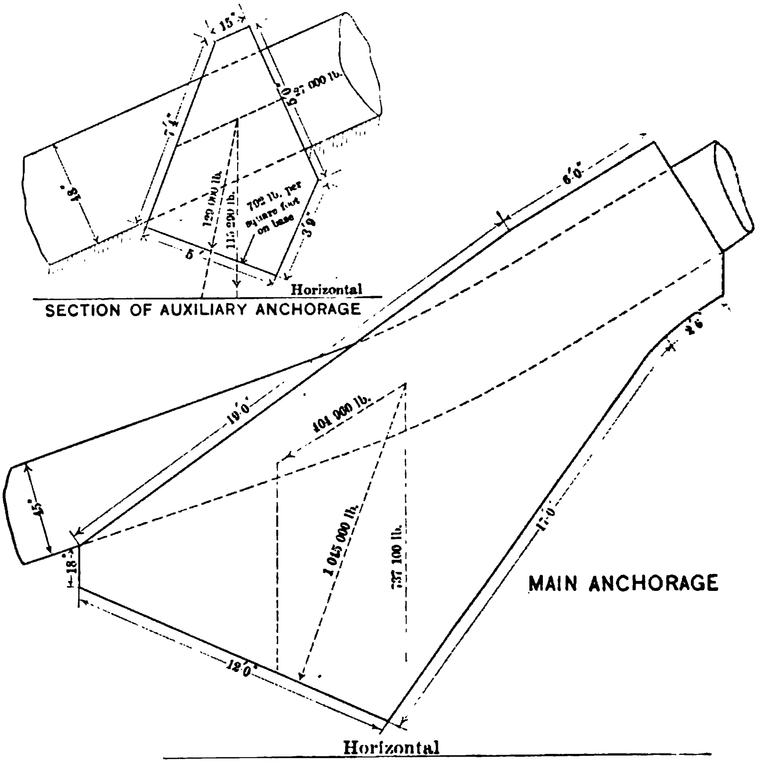


Fig. 7.

PLATE XLV.
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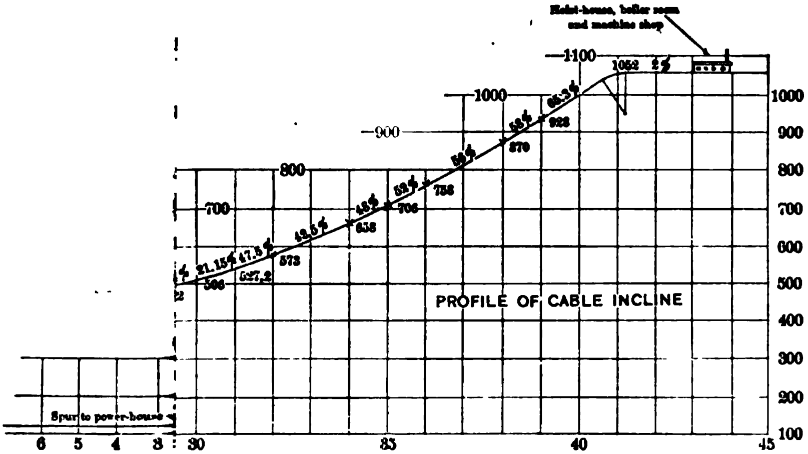
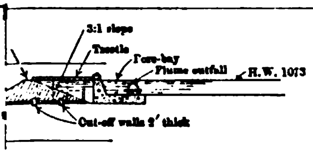
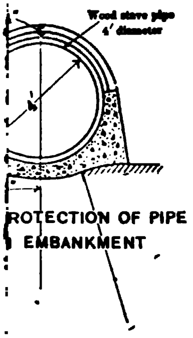
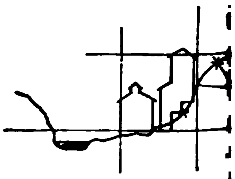
MAY, 1905.
WARNER ON
HYDRAULIC POWER PLANT.


PROFILE OF CABLE INCLINE




ROTECTION OF PIPE
EMBANKMENT



and was let by contract to Messrs. Bihler and Rydstrom at $10.50 per cubic yard. Within the power-house the pipe trenches were back-filled with concrete to a depth of 18 in. above the top of each pipe.

Power-House.—The generator-room, 42 by 150 ft., up to the crane runway, 28 ft. above the floor level, is built of concrete. Above this, to a height of 12 ft., the construction is of brick. The front wall has a thickness of 24 in., and is strengthened at intervals of 29 ft. by pilasters. Below the floor level, the foundation wall consists of three piers, 7 by 8 ft. at the base, and two abutments, 4 ft. thick and 19 ft. long, connected by elliptical arches, of 22 ft. span. The arches are reinforced with 35-lb. steel rails bent to approximate the form of the arch.

One abutment and the adjoining pier are founded on piles driven 30 ft.; a concrete grillage, with steel-rail reinforcement, covers the heads of the piles. A similar foundation supports the footing course for Units Nos. 3 and 4; but, in all other foundation work, bed-rock was reached.

Back of the generator-room there are three transformer-rooms with steel-roller shutter doors. A switching gallery, to which access is had by an iron stairway, occupies 20 ft. of the east end of the building. The gallery is supported on cast-iron columns, and has a 4-in. steel and concrete floor, reinforced with wire netting. The crane runway is of 60-lb. steel rails bolted to a 24-in. I-beam anchored in the wall. The crane, furnished by the Cleveland Crane and Car Company, of Cleveland, Ohio, has a 50-ton main and a 5-ton auxiliary hoist, run by 25 and 12 h-p. motors, respectively; these, with a 25 h-p. motor for the bridge travel and an 8 h-p. motor for the trolley, complete the crane equipment.

The roof is of steel trusses spaced at 14 ft. 6 in. centers, with 6 by 10-in. purlins bolted to the trusses, and covered with matched lumber and galvanized corrugated iron. The contract for the power-house was let to Messrs. Bihler and Rydstrom at the following prices: Excavation, $19 860; concrete, $7 per cubic yard below floor level, and $8 per cubic yard above floor level; brick laid in cement mortar, $25 per thousand; erection of crane and runway, roof, doors and windows, $4 567.

In the generator-room are installed four units and two exciters.

Each unit consists of a General Electric 3 500 kw., three-phase, 60-cycle generator with rotating field separately excited. The rotor is mounted on a nickel-steel shaft, running in water-cooled bearings, and lubricated under pressure. On the overhang, at each end, is a Pelton wheel, 8 ft. 8 in. in diameter at the flow line, and making 225 rev. per min. The shaft is hollow, with a 7-in. bore; its diameter is 14 in. at the wheels, 16 in. at the bearings, and 20 in. at the rotor. The rotor and wheels were pressed on over feathers with a 200-ton hydraulic jack; the pressure at which they went on averaged 125 tons for the rotor and 120 tons for the wheels.

The wheel discs and buckets are solid cast steel, the latter bolted on with forged-steel bolts.

Water is admitted to the wheels through Y-branches, 25-in. in diameter, bolted to the flanges on the 36-in. penstocks. Each branch is provided with a motor-operated gate and a by-pass. A needle deflecting nozzle, with a Lombard governor, type L, and automatic control, regulates the flow to the wheels. The contract for the wheels, shafts, bearings, Y-branches, gates, regulating devices and floor plates, was let to the Pelton Water Wheel Company, of San Francisco, Cal., for $75 000, erected, the makers guaranteeing an efficiency of 80% and 75%, respectively, at full and half load.

The governor water is supplied by a tank, 14 ft. in diameter and 13 ft. 6 in. high, made of 3½ by 4-in. staves, with a 3-in. floor, located 460 ft. above the power-house floor. A 2½-in. header, with valves, connects the four mains and the exciter main at the upper end of the steel penstocks. From the header a 4-in. pipe discharges into the tank, from which a 5-in. pipe leads to the governors.

Provision has been made for an auxiliary supply, from a small stream near the reservoir, in order to insure clear water if floods in the river should render the flume supply unsuitable.

Each exciter consists of a General Electric, 150-kw., 125-volt, direct-current generator, driven by a 36-in. Pelton wheel making 600 rev. per min. For use independent of the wheels, an induction motor is mounted on the same shaft and takes current from the generators at 2 300 volts. Provision is made for a third exciter to accompany the next installation.

The exciters, in addition, furnish current for the crane, the station lighting and the machine shop. Motor-driven pumps, for

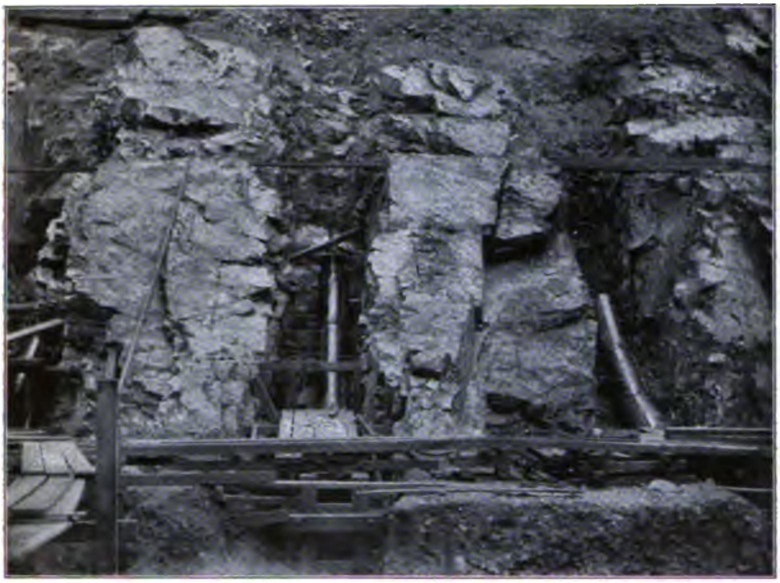


FIG. 1.—TRENCHES FOR PIPE LINES AT POWER-HOUSE; SHOWING BLOCKY NATURE OF GROUND.

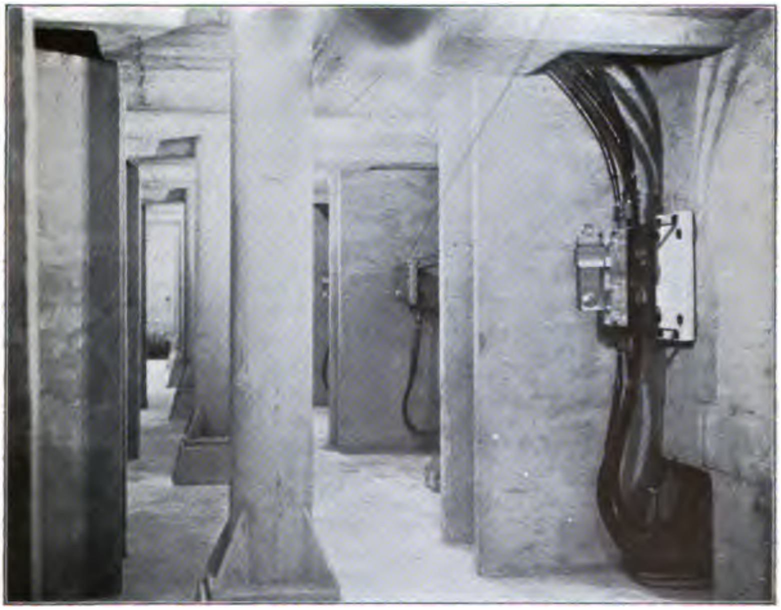


FIG. 2.—LOW-TENSION DISCONNECTING SWITCHES, WITH BARRIERS.

water circulation and pressure oil-lubrication, are located beneath the floor at the end of the building. The direct and return pipes are carried in a duct below the wheel and generator pits running the length of the building.

Each transformer-room contains three General Electric, 2 333-kw., oil-insulated, water-cooled transformers, which raise the initial voltage of 2 300 to 55 000.

In this work, 122 piles were driven, and 3 000 cu. yd. of concrete put in. A 1 : 3 : 6 concrete was used. The cement was a California Portland, giving, on a 7-day test, 400 lb. ultimate tensile strength. The sand and stone were of the same quality as described previously.

Switching-House.—This building is 52 by 150 ft., and is located back of the generator-room, with a 4-ft. air space between. It is of concrete, with the exception of the top floor, which is a wooden frame covered with galvanized corrugated iron. The concrete was a 1 : 3 : 6 mixture, as described previously, and was used throughout, including that for the 4½-in. floors reinforced with wire netting.

Pieces of this flooring, 4½ by 12 in. and 6 ft. long, with the reinforcement, were made from the run of the mixer, and were broken subsequently, with the following results: The test pieces were broken with a lever and weights, the center bearing being 4½ by 12 in. and the span 5 ft.

Number.	Broken after:	Broke at:
1	21 days	720 lb.
2	28 "	856 "
3	36 "	1 037 "
4	111 "	1 424 "

The wire netting was made up of two No. 10 wires twisted into one strand. The strands were 4 in. apart, and were tied with one No. 12 wire, making a triangular web.

Rather than impose a further burden of work on the power-house contractors, a company's force was organized, and the work was done by day's labor. The cost of the concrete laid in this way, including 4-in. barriers, shelves for low-tension bus-bars, and 4½-in. floors, was $10.40 per cubic yard.

The first floor is the low-tension disconnecting-switch room, with switches separated by 4-in. concrete barriers. The second floor contains the oil-break switches and a double set of low-tension bus-bars carried on concrete shelves. The third floor contains the high-tension disconnecting switches, and the fourth floor, the high-tension bus-bars, oil-break switches, and lightning arresters; and from here the cables pass out of two towers, to the pole line.

Transmission.—A double pole line is used for transmission. The poles are from 90 to 115 ft. apart. A cross-arm carries two cables, and the head of the pole a third, making a 6-ft. triangle. Each cable is composed of 19 copper wires, equal to one 0000 wire.

Triple-petticoat insulators, furnished by the Thomas and Locke Companies, and tested to 140 000 volts, with satisfactory results, were used.

The company did all the work preliminary to construction, clearing the flume line and the reservoir site, the flume substructure, and the grading for the penstocks, the switching-house and the concrete protection of the wood-stave pipe, and the back-filling of the pipe lines.

Prior to April 15th, 1903, a wagon road to the reservoir camp, and a pack trail from there to the head-works site, had been built, and the reservoir site and penstock line cleared of heavy timber. On April 15th, 1903, the serious work of construction began. On March 21st, 1904, one exciter was furnishing power for the crane motors and the station lighting. On April 12th, 1904, Unit No. 1 was delivering power to Tacoma for commercial purposes, and on July 23d, Unit No. 4 was put in operation, completing the installation.

TABLE 2.—ELEVATIONS.

	Elevation.
Crest of dam	1 148.0
Floor of intake	1 142.4
Flume, at outfall	1 065.5
High water in reservoir	1 073.0
Top of embankment	1 078.0
Bottom of reservoir	1 059.0
Center of nozzle, at power-house	201.5

Only three fatal accidents occurred during the progress of the work, none of which could have been prevented, by even more than the care ordinarily exercised. Minor accidents, such as cuts and

PLATE XLVII.
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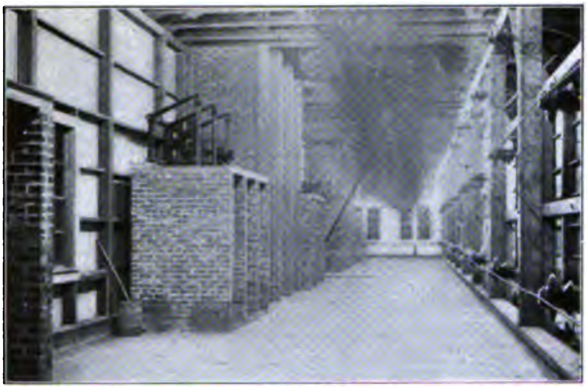

FIG. 1.—HIGH-TENSION ROOM. SHOWING BUS-BARS, OIL-BREAK SWITCHES AND LIGHTNING ARRESTERS.

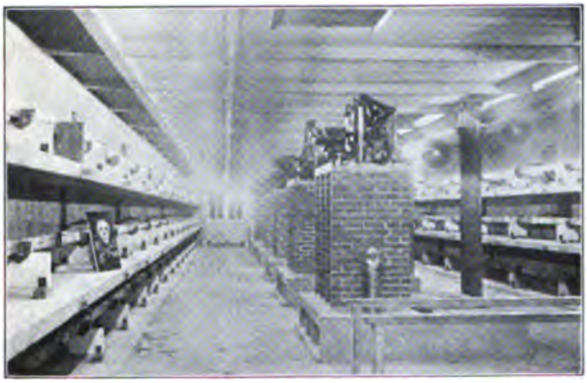

FIG. 2.—LOW-TENSION ROOM, SHOWING BUS-BARS AND OIL-BREAK SWITCHES.

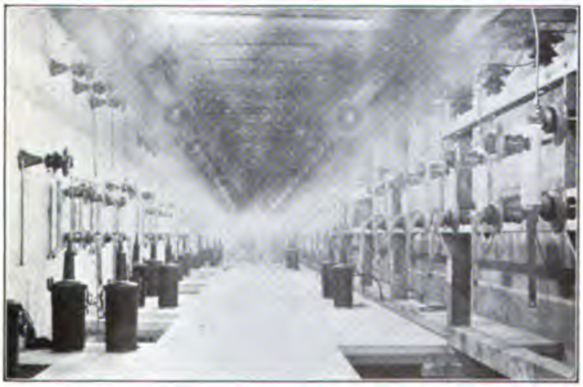

FIG. 3.—HIGH-TENSION DISCONNECTING SWITCHES.

bruises, were, in number, only such as might be expected with a force of 1 500 men. The total cost of the work approximates $125 per horse-power, a portion of which is properly chargeable to preparation for the second installation of 20 000 h-p., which, when made, will reduce the cost to approximately $90 per horse-power developed. The Columbia Improvement Company is a subsidiary company, of the Stone and Webster Syndicate, formed for construction purposes.

Table 2 shows the elevations of the principal points on the works.

The static head on the Pelton wheels is the difference between 1 073, the elevation of the surface of the water in the reservoir, and 201.5, the elevation of the center of the nozzles, equal to 871.5 ft.

The Pelton Water Wheel Company contracted to supply and erect the wheels, guaranteeing under penalty an efficiency of 80% at full load and 75% at half load for the four 3 500-kw. units, under an effective head of 850 ft.

The writer's connection with the work began in April, 1903, and ceased on August 15th, 1904, or three weeks after the fourth unit had been installed and put in service, and he is not aware that any determination of efficiency has yet been made. It is unfortunate that the company failed to respond to a request for means to standardize the gauges as a preliminary to the tests. By inspection of the gauges under varying conditions, however, the writer was able to approximate a correction which resulted in the following:

Surface of water	1 059	ft.
Elevation of center of nozzle	201.5	"
	857.5	"
By gauge corrected	850.3	"
Loss of head	7.2	"

This is not very satisfactory, and it is to be regretted that means were not furnished for flow measurement in so large a pipe under such conditions of high head. These measurements must be made later to determine whether or not the Pelton Water Wheel Company has met its guaranty. When made, the writer hopes to be able to obtain the results.

Vol. XXXI. MAY, 1905. No. 5.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PAPERS AND DISCUSSIONS.

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NOTES ON THE IMPROVEMENT OF RIVER AND HARBOR OUTLETS IN THE UNITED STATES.

By D. A. Watt, M. Am. Soc. C. E.

To be Presented September 20th, 1905.

The experience available at the present time, from improvements of the mouths of rivers and harbors, is in no single country as extensive as in the United States. For more than 30 years, work of this nature has been carried on, embracing the coasts of the Atlantic and Pacific Oceans and of the Gulf of Mexico, and varying from rivers draining a small portion of one State to rivers like the Columbia or the Mississippi, and from harbors of local magnitude to those having an importance which has grown to be world-wide. Many of these works, as is well known, have met with success, while others have not fully realized the hopes of their engineers, and have served to emphasize the fact that the operation of the laws governing the improvement of the outlets of rivers and tidal harbors is complex and very difficult of analysis.

In no department of hydraulic engineering does there appear to be a greater absence of precise knowledge, nor anywhere that a plan for improvement may be more likely to produce divergence of

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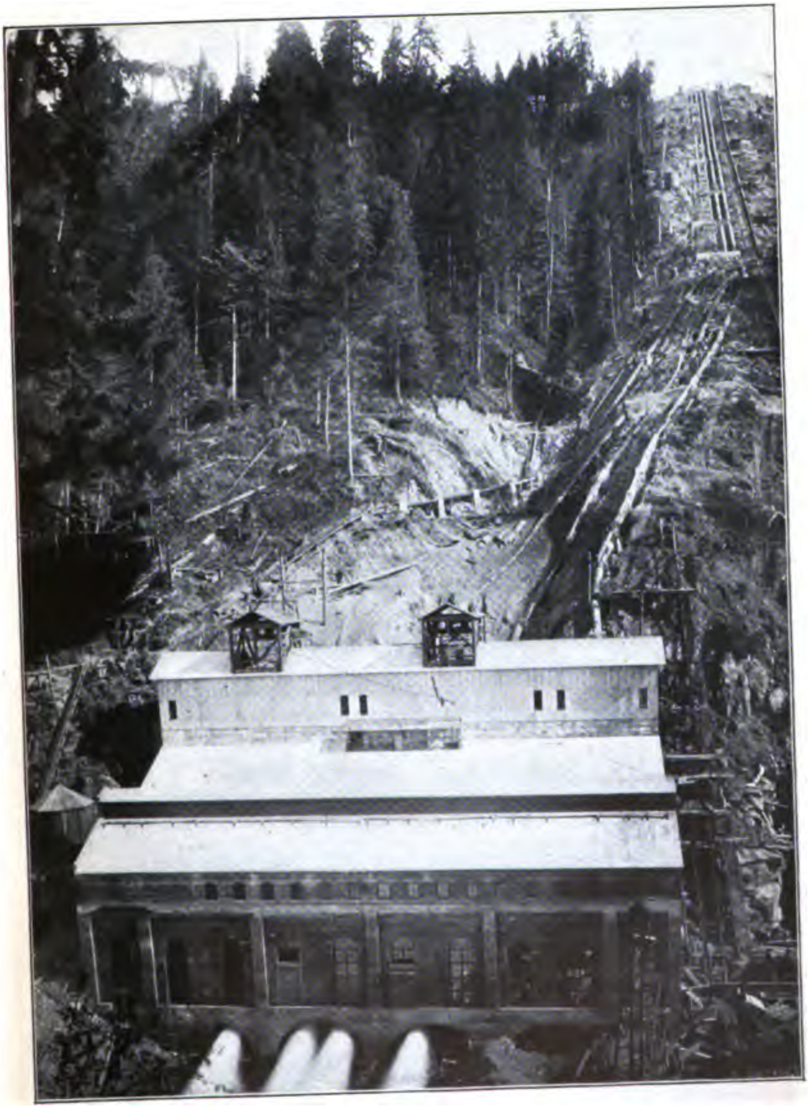
Note.—These papers are issued before the date set for presentation and discussion. Correspondence is invited from those who cannot be present at the meeting, and may be sent by mail to the Secretary. Discussion, either oral or written, will be published in a subsequent number of *Proceedings*, and, when finally closed, the papers, with discussion in full, will be published in *Transactions*.

PLATE XLVIII.
PAPERS, AM. SOC. C. E.
MAY, 1905.
WARNER ON
HYDRAULIC POWER PLANT



PENSTOCK LINES.

NToU

opinion. Thus, with the improvements proposed some years ago, but never executed, for training works in the Estuary of the Mersey, engineers of wide experience advanced almost contrary views; and, for the improvement of the Estuary of the Seine, submitted to the best engineering talent of France, fourteen different projects were brought forth.

The forces at work are usually many and varied, and, while the effect of their action singly upon a plan might be foretold, their action in combination can only be approximated. There are, for example, the following: The transportation and deposit of the sediment present in most rivers; the effects of floods and tides; the presence or absence of currents along the coast; and the gradual effects of storms and of the drift of shore material, which, with small rivers, may change the outlet entirely, as with the Yare, on the East Coast of England, where the outlet has been driven south 4 miles in the course of time. Such causes, in some instances, produce daily changes of channel, as with the Hoogly, which ships can navigate only in daytime and by constantly taking soundings; in others, the movement is more gradual, as with the Estuaries of the Thames and the Seine; in others, again, the movement may occupy many years. Occasionally, other forces are also met, the causes and effects of which are equally obscure. Thus, at the Harbor of Madras, during the construction of the jetties, certain portions of them, in a depth of from 18 to 20 ft. of water, were frequently covered 3 ft. deep with sand during seasons of calm weather, and with no perceptible littoral current, nor any visible cause of disturbance except the ground-swell.*

Seeing the amount of material at hand, the writer was tempted to investigate, as far as a restricted leisure would allow, the conditions at several localities before and after improvement, with the object of ascertaining whether some general principles had not been manifested by the natural forces in the interval, or special experiences gained, which might serve as a guide in planning future work. During his connection with river engineering he has had frequent cause to study the effects of the laws of flow, and of their influence, as shown by Nature, on the formation of banks and channels, and the question naturally arose as to how far the same laws would be found to hold good when modified by the conditions usually existing at outlets. In investigating the matter he was fortunate enough to have access, among other publications, to a complete set of the Coast Survey charts of the United States, as well as to the data and maps of the Reports of the Chief of Engineers, U. S. Army, for the last 25 years. The principles corroborated by this study, and the generally accepted theories of the subject, are summarized herein. They are submitted to the Society in the hope that they will be criticised by members of riper experience in this field.

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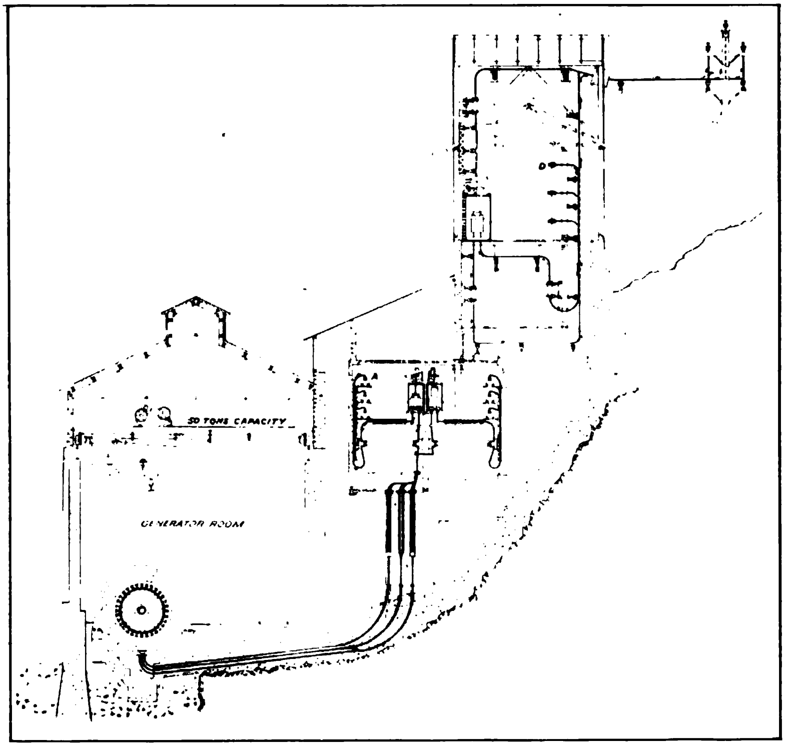
* *Minutes of Proceedings*, Inst. C. E., Vol. C.

1.—A body of flowing water, when preserving a constant or comparatively constant width and depth of channel, appears as moving in a curve. It is when the current crosses from one side to the other, or flows in a straight reach, that the channel becomes shallower or uncertain. To produce a permanently satisfactory channel, therefore, by training works, the latter must be located so as to permit the water to travel in a curve.

2.—In alluvial material there appears to be a fixed relation between the curvature and the best attainable conditions of channel. Where the natural curvature is increased, the channel becomes wider and of less depth; where it is decreased, the channel becomes deeper and narrower.

3.—At every outlet there usually exists, in some part of it, or has existed before improvement, a channel indicating the limiting dimensions, as regards depth, width and curvature, which the local flow is capable of producing, these dimensions being the final resultant of the velocity, the scour, and other local forces and conditions.

4.—The channel to the bar, commencing at some point within the outlet (or the main channel, where there is more than one), is usually found existing as a reversed curve the arcs of which are united by a tangent, or as a series of reversed curves and tangents; and the direction of its bar crossing is indicated, even in shifting outlets, with more or less constancy, being the resultant of the tides, winds, sand-drifts, etc. If the distance to the bar is short, the reversed curve is often of approximately equal radii. Exceptions to this rule are frequently due to the presence of hard shoals or bars, or similar obstructions which the water has not been able to scour away, or to the temporary effects of storms.



Power House. Cross-Section Looking East, Showing Circuits Nos. 1 and 4.

5.—To secure the full success of the improvement, it is essential that these natural resultant conditions of location and curvature, especially as regards the bar crossing, be interfered with as little as possible. Any attempt to divert or change them, when jetties are used, will reduce the scouring power of the water, which will tend constantly to return to its original and natural location; and, if the diversion is marked, and the jetties of much length, the power of the water may be dissipated and lost by the time it reaches the bar. If the curvature be reduced, with the object of producing a deeper channel, the latter will be forced against the jetty, and is likely to become restricted in available width until ships are hampered in their movements. If the curvature be increased, it appears that there is a danger of the channel impinging on one or other of the jetties with similar results, in its attempt to preserve its original location.

6.—Where the works of improvement have been located so as to accord with and preserve the natural tendencies of curvature and location, and the jetties have been carried to deep water, the pushing of the bar seaward, the drift of sand along the coast, etc., appear to have produced only a small portion of the trouble usually apprehended. Conversely, where jetties have not been sufficiently extended, or the natural tendencies have been disturbed, these sources of trouble have always been more or less in evidence. As long as the waves can disturb the bottom, it is difficult for jetties to produce the removal of the sand brought upon the bar, and which is more likely to accumulate in such circumstances, because the jetties partly shelter it. The effects of waves can disturb rubble to a depth of 20 ft. below the surface, where the construction is such as to cause a violent reaction, and, with ordinary reactions, a light material is no doubt disturbed to a greater depth. The practical value of jetties properly located appears to result from the protection of the flow of water from the disturbing effects of waves, coast currents, and sand-drift, until it has passed the bar and reached water of depth sufficient to neutralize the effects of these forces upon the channel, rather than from any actual training of the channel itself. If the water is provided with suitable scope and protection, it will work out, of its own accord, the best results obtainable at the outlet.

7.—Where two jetties are to be used, and construction will be rapid, they should be advanced together, so as to preserve the balance of the water in creating its new channel. Where one jetty is built in advance of the other, at localities where marked sand-drift exists, it usually results in deposits on one side or the other, which the water has to deal with later. To obtain the full scour, the jetties should be raised at least to ordinary high tide; results with half-tide or low-tide jetties have been less satisfactory than when the same jetties have been raised later.

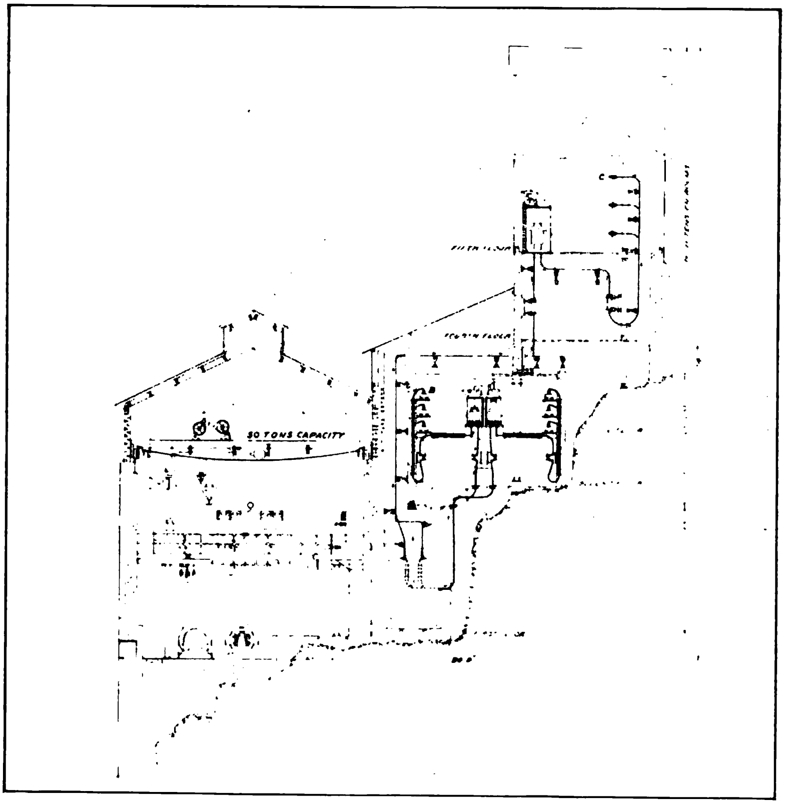
8.—Rapidity of construction has come to be recognized as an essential of success. Where the work has been prolonged for several years, the result has usually been that the seaward movement of the bar and foreshore has kept pace with the extension of the jetties, and the latter in consequence have had to be prolonged beyond the original needs of the case. In addition to this, the location of the channel to be improved may be altered entirely by the periodic change going on at almost every outlet, and this change may result in permanent injury to the waterway and greatly increased expense.

9.—If much sediment is carried, or where immediate results are desired, it will be advisable to assist the removal of the bar by dredging. If this is not done, under the former conditions, the sudden contraction of the outlet by the jetties may cause serious deposits of sediment above, such as occurred during the improvement of the South Pass of the Mississippi.

1 and 2.—The first two statements comprise principles well known to everyone who has had cause to study rivers from a practical standpoint, and need no comments. M. Fargue, at the International Congress of Navigation of 1892, was the first, it is believed, to place on record these and other laws in a concise summary of the effects of flow as he had observed them in his studies for the improvement of the Garonne.

3.—According to the third statement, the limit of improvement is shown more or less clearly by existing natural conditions; and if a certain depth and width is desired for the improved channel, that depth and width must appear as already existing naturally in the outlet, or it will not be obtained except by artificial means, such as dredging. In the majority of cases, except those of funnel-shaped estuaries, the charts were found to show the water as entering the sea in a well-defined channel or gorge, which continued toward the

PLATE L.
PAPERS, AM. SOC. C. E.
MAY, 1905.
WARNER ON
HYDRAULIC POWER PLANT.



Power-House. Cross-Section Looking East, Showing Circuits Nos. 2 and 3.

bar for a greater or less distance, depending on the slope of the ocean floor, before it shoaled and became uncertain. Where the floor is of steep slope, the waves and other outside forces bewilder the flow soon after it leaves the shore line, but where the floor is comparatively level, the flow usually continues its course for some distance before it is overcome, and builds out a protection of sand-bars and banks in the shallow water, sometimes for long distances from the shore, in the same way as a delta-forming river builds out into the sea, and protects itself between the banks until the flow can retain its natural elements of location undisturbed. It is the elements of this channel at or near the shore which seem to indicate the limits of an improvement, since they are the resultant of the principal causes, namely, the flow of water and the conditions of the banks, both within and beyond the shore line, which direct that flow; and, unless these causes are altered, their resultant must remain unchanged. Jetties appear to act as protecting banks, and in their shelter the flow of water will endeavor to regain and establish permanently its natural tendencies.

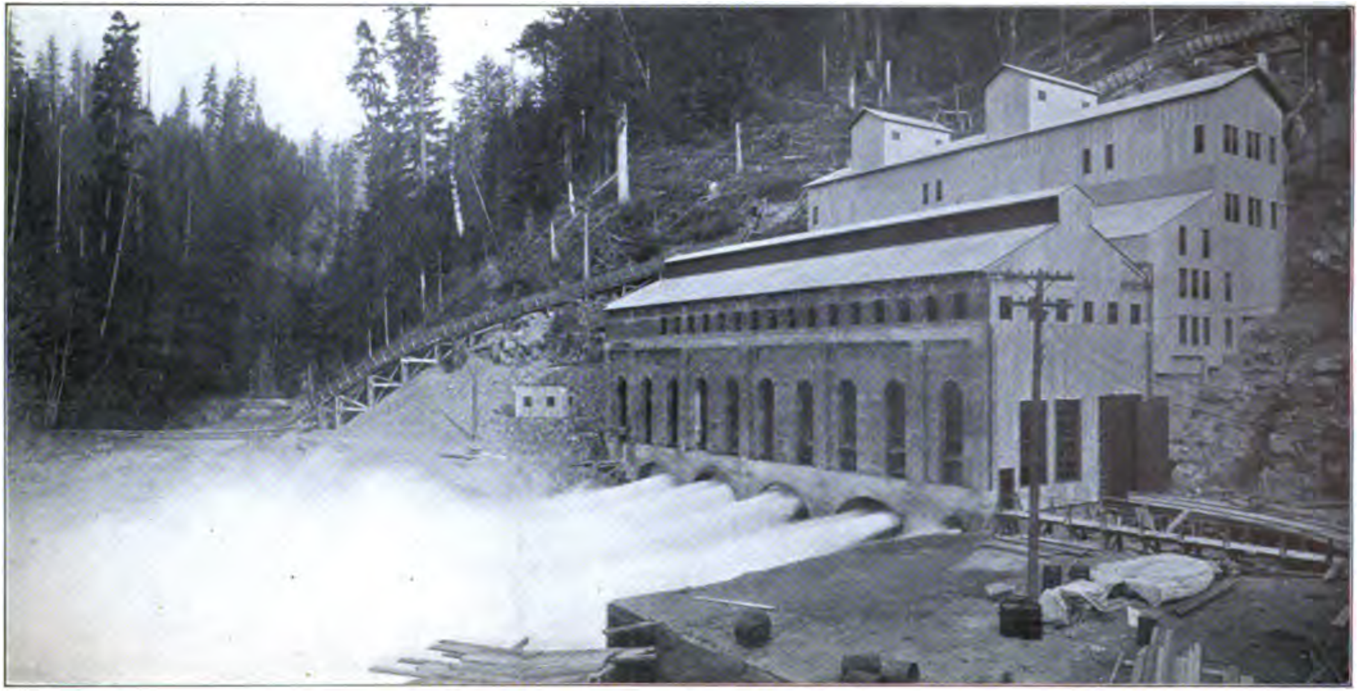
It was observed that at several unimproved minor entrances, especially on the Gulf Coast, where the normal tide range is about 13 in., good depths of water existed, but the curvature necessary to maintain them was so abrupt and the channel so narrow that only small vessels could navigate them. In such cases a curve of width adapted to an improved channel could only be produced by using a longer radius, with a resulting loss of depth, and danger of spoiling the entrance. Experience with improved channels, however, in rivers improved by regulation, as well as in estuaries or harbors, indicates that the natural curvature can be safely changed only within very narrow limits, because, as stated further on, flowing water displays a marked persistence in adhering to the location found in its natural condition.

As would be expected, the outlets which carry a large volume of water appear almost invariably as of large radii, while those of small volume are of small radii, there being evidently an intimate relation between the volume and the curvature.

4.—The fourth statement describes natural conditions, which can be verified by an examination of coast charts or similar data. The general resultant tendency of flow toward the bar, in the great majority of instances, appears to be about at right angles to the neighboring coast line, or along the shortest path to deep water, this being ordinarily the line of least resistance and the one which the force of the water would therefore naturally take. The channels on leaving the shore maintain their respective widths and depths with considerable regularity for some distance toward the bar, this distance being generally in proportion to the distance of the bar off shore. Another feature is that at nearly all the larger outlets, both on the coasts of the two Oceans and of the Gulf, there are, or were, two channels to the bar (in addition to the small side or "swash" channels) which deepen and shoal alternately during a cycle of change, and shift their location within a sector of a circle covering an angle usually from 45 to 90°, but never exceeding fixed limits. On the South Atlantic Coast, for example, the channels swing generally between east and south, one or two cases being in evidence where the main channel, as at Charleston Harbor, ran parallel to and near the shore in a southerly direction. Usually, however, the channel leaves the shore at once. On the Pacific Coast the variation, as a rule, appears to lie between southwest and northwest. The cycle of change seems to take place as follows: Suppose the main channel to be the southerly one. After it has continued in existence for a few years, it will begin to shoal, possibly on account of a period of gales, possibly from the more obscure causes by which Nature works out her cycles. At the same time the northerly channel will begin to open, and the closing of the southerly one will continue until it has become valueless for shipping. Usually more or less change of location occurs at the same time, the channels sometimes wandering over a considerable portion of their field before the final shoaling or opening occurs. The northerly channel will then pass through a period as did the other, and may shift further north, gradually deteriorating until the natural forces close it, and the water breaks open again along its first direction to the south. As far as known, the regularity of these cycles is a matter of doubt; at some outlets, a change such as just described has taken place in a few years' time; at others, the channels have remained almost stationary for a long period. The question could probably be decided only by a very protracted series of observations.

The "middle ground" lying between these channels, and which in

PLATE LI.
PAPERS. AM. SOC. C. E.
MAY, 1905.
WARNER ON
HYDRAULIC POWER PLANT.



Power-House, Showing Four Generators in Operation, and Trenching and Grading, at the Right, for Four Additional Units.

closed estuaries is found inside the outlet as well as in the open sea, is the natural result of a sediment-bearing flow meeting still water. The greatest amount of heavy sediment, being carried along the center or deepest portion of the water, is deposited gradually as the flow slackens, and begins to form a bank along the middle of the channel, which builds up and forces the side flow, carrying lighter sediment, to one side, until the water is finally divided into two channels with the more or less stable middle ground between.

5.—The contention of the fifth statement is that the natural conditions as then existing should control the location of the jetties, or of the dredging, where such is to be done, under adherence to the fact that the location and dimensions of the channel are the effects of those natural conditions, and cannot be altered, except within very narrow limits, unless the causes themselves are altered. Experience with the regulation of rivers, as before mentioned, has shown that the more closely the tendencies of flow and channel can be preserved the more successful will be the improvement, and that any forced change produces disturbances in direct proportion, and the same laws are applicable to outlets. It was observed that where, in improving outlets, attempts had been made to divert the flow, as, for example, with the intention of scouring out a portion of the bar not crossed naturally by the channel, or in order to make the channel more direct than shown in its natural location, there was always in the completed work evidence of a disturbed balance of forces, the water striving to keep its former path, and the jetties resisting its efforts, and in extreme cases so breaking its strength that it wandered to the sea between the works in a bewildered and constantly shifting channel. The evidence with dredged channels was the same, except that the path of the water was not hampered, and it merely refilled the cut or such portions of it as did not accord with the direction of the flow.

As examples of the inherent tendency of the water to follow its chosen path, the improvements of the St. Johns River, Florida, of the South Pass of the Mississippi, and of Galveston Harbor, Texas, may be cited.

The St. Johns River work belongs to that class where appropriations have always been moderate; and it has suffered in consequence much in the same way as did the work at Cumberland Sound, described further on. The outlet in 1879 presented the usual feature of two channels, one of which ran about northeast, the other about east-southeast. The former was the ship channel at that time, and, accordingly, was chosen for improvement when work was begun, about 1880. The general conditions are shown on Plate LII, and it will be noted that the map of 1879 shows the main flow of water striking the future line of the south jetty in the vicinity of the squares marked 3 and 4.* During the twenty-five succeeding years, in spite of the gradually increasing influence of the jetties, the flow has continued to impinge upon the same zone, along almost the same direction; and, even during short periods, when the maps show the channel attempting to divide and to open more fully its northerly arm, the southerly one still kept to its old location, and impinged on the jetty about at the original angle.

A somewhat similar case is to be seen in the improvement of the Estuary of the Seine, now being carried on. The new training dike on the south side makes an angle with the old dike below Berville in such a manner that it cuts into and partly deflects the natural location of the flow, and the latest map shows a deep reaction hole scoured out at the point of impact (with no doubt a corresponding loss of force), such as appears on the south jetty of the St. Johns.

In the case of the South Pass of the Mississippi, Plate LIII, the change in the natural location, which was slight, was made at the bar. The writer had been informed some years ago by officers of steamships plying to New Orleans that just in front of the jetty entrance there lay a mud bank which was a source of considerable trouble to shipping, especially when the river was in flood. It necessitated a sharp turn to a course about northwest or southeast, according as a ship might be entering or leaving, which a large vessel could not always make in time, and if caught by the current when going out, she would be driven upon the bank, or, if coming in, would go ashore on the jetties. Of this he had a practical illustration when entering the Pass on a vessel a few months ago. His vessel was preceded by a steamship of some 3 000 tons, which made the turn safely past the bank and headed for the jetty entrance. The current, however, was strong, the river being in flood, and before

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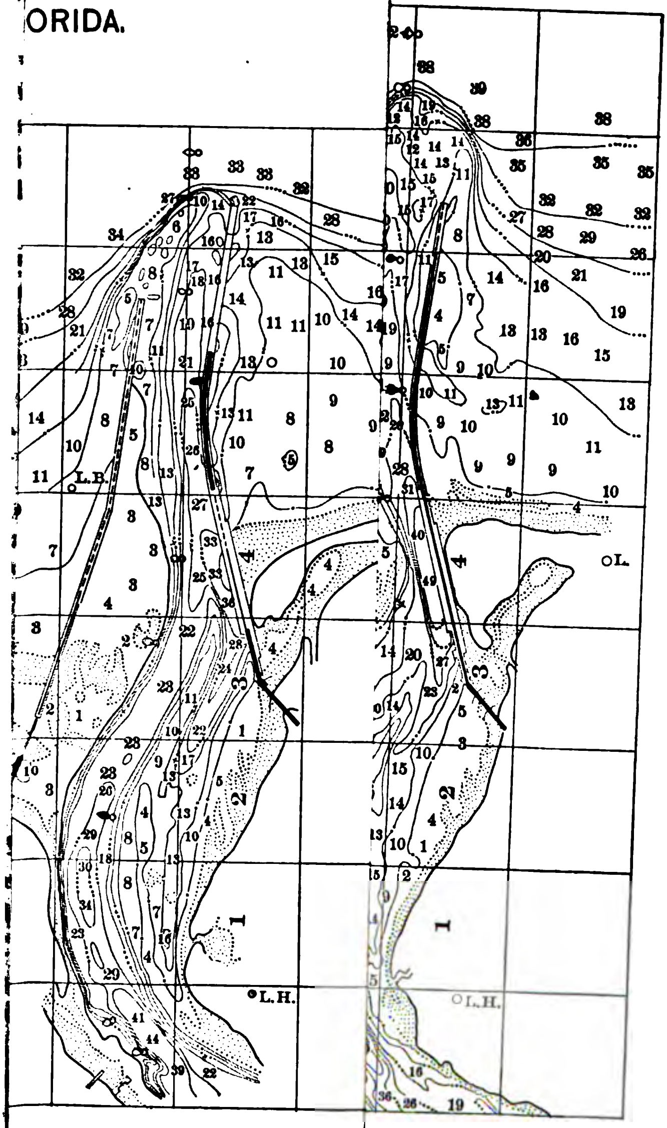
* The maps from which Plate LII is compiled are taken from an unusually complete and valuable series made by the Engineer Department, U. S. Army, showing the changes annually (with a few exceptions) since 1879.

PLATE LII.
PAPERS, AM. SOC. C. E.
MAY, 1906.
WATT ON
RIVER AND HARBOR OUTLETS.

ORIDA.



Water
“
nd M.H.W.
High Water

the pilot could straighten up the ship in the narrow channel, the current began to swing her, or, as sailors say, she "took a sheer," and went hard aground on the east jetty.

While damage to shipping rarely results from such accidents, the expenses for tug hire and the loss of time have been a source of considerable complaint from ship-owners. On making inquiry as to whether this sharp curve in the channel, and the bank which existed in spite of its location opposite the discharge from the Pass, might not be indications of some change having been made in the natural position of the outlet, it was found from the description of the Engineer-in-Charge that such was the case. It is stated as follows:*

> It is an observed fact that delta-forming rivers, when they enter the sea, have a tendency to direct their currents against the littoral currents of the sea, for the reason that the suspended sediment which they discharge is carried by the sea to the leeward bank of the river, and the accretions, which are made upon this bank from the river discharge, cause it to grow more rapidly than the other, and finally to curve the fluvial current around against the littoral current. * * * The prevailing littoral current (at the Pass) is from the east. * * * To direct the current from the Pass completely at right angles with the littoral current would have been very desirable."

The writer of the foregoing continues to state that it was feared, however, that by forcing the current too far from its natural location the concave or east jetty might be undermined, and that the final location of the ends of the jetties was a compromise between the desire to make the river discharge at right angles to the littoral current, and the apprehension that by so doing too much scour might result along the east side.

The correctness of the views expressed in the quotation has been abundantly verified since the jetties were completed in 1879. The chart of that year† shows the bank beginning to grow on the west side, while the accretion shown there on the chart of 1889, and its absence on the east side, is very noticeable. It is this shoal which is the cause of the trouble to shipping above referred to, and the direction of the discharge into the Gulf appears on the various annual charts of the outlet, published by the Chief of Engineers U. S. Army, as adhering to the same course (about southeast) as i pursued in its natural state, and before any effort was made t deflect it.

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* "The Mississippi Jetties," E. L. Corthell, M. Am. Soc. C. E., p. 73.

† The charts of 1875 and 1879 are reproduced by permission of E. L. Corthell, M. Am. Soc. C. E., from "The Mississippi Jetties"; those of later years are from surveys by the Corps of Engineers, U. S. Army.

Although this deflection was slight, the river has persisted i attempting to hold and to regain its former and natural direction and this tendency and the axis of free discharge, appear to hav remained constant for the past twenty-five years. The Pass ap- proaches the sea in a series of very flat reversed curves, the las point of reversion having originally been near the northern ends o the jetties. The latter, trending to the south, transformed the fina reversed curve into a simple curve which the river follows until it is freed from their influence at the mouth.

The tendency of the river to build up its west bank is a noticeable feature, as for many miles it is separated from the Gulf only by a narrow tongue of land on the east, while on the west the deposits have built up an area several miles across. The general direction in approaching the delta, however, is steadily southeast.

Another point in connection with the formation of the new channel seems worthy of note. In order to accelerate the scour at the upper end, over a portion of the bed somewhat compact, there were built on the east and west sides, during the fall and winter of 1876, some short spur-dikes above the deep basin shown on the chart of 1879. The main jetties, apparently, were then being built up, so that the stream was beginning to feel their restraint. During the floods of the following spring the deep basin shown on the chart just mentioned began to appear, scouring out to a depth of 95 ft., which, however, was reduced to 75 ft. as the river deposited its sediment during the summer and fall. In the floods of the next year (1878), however, the basin was scoured out again, reaching a depth of 114 ft. The conditions becoming dangerous, and the object of the spurs having been accomplished, those on the west side were cut back to the line of the jetty, alleviating the evil. The basin, however, still continued to exist at about the same point, as shown on the charts for 1879 and the years following, up to 1882. That for 1883 shows the basin with a depth of about 74 ft., and moved up a short distance above the commencement of the west jetty. This change was probably due to the approach of the

PLATE LIII.
PAPERS, AM. SOC. C. E.
MAY, 1905.
WATT ON
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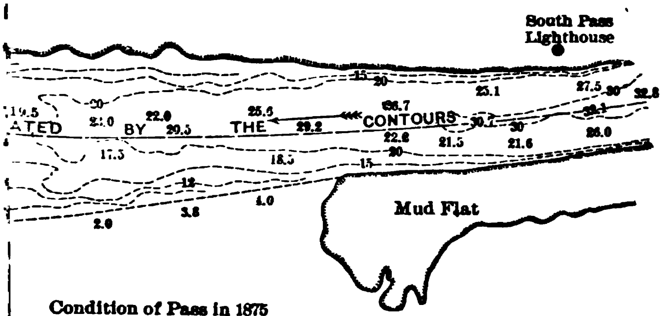
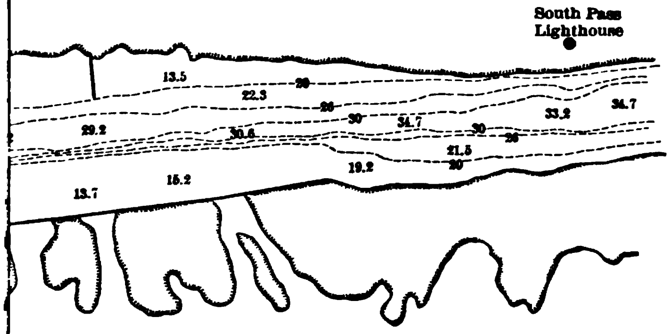


Condition of Pass in 1875
From special survey



, 1879,
Spur Dikes

inner east jetty, which, in the interval, had been built up stream until it impinged on the lower end of the basin and forced it up the river. In 1884 the depth was about 57 ft., and the location the same as in 1883; by 1886 it had shoaled to about 43 ft., and the approach of the inner west jetty was causing the final break-up of the reaction. By 1888 the inner jetties had so narrowed the stream that it was forced at last into a straight flow, and the basin filled up to the general profile of the bed.

At the time of its appearance, this tremendous scour was attributed to the effects of the spur-dikes just constructed. Whatever the cause, the effects were precisely those which have appeared in similar cases where the flow of a river has been trained out of its natural course, and where, there being no spur-dikes, the disturbance can be accounted for only on the rational ground of interference with the natural tendencies. Thus, it is to be noted that the basin was formed along just that portion where the west jetty crossed the natural channel, as can be seen by a reference to the chart of 1875, and where, in consequence, a basin ought to have appeared, as actually appeared on the St. Johns River, and on the Seine, before mentioned. The scour also was worse on the west, the former channel side, since it is stated that in 1877 it undermined the foundation mattresses of the west jetty to a depth below water of 30 ft., while no trouble appears to have been caused on the east.* When no steps are taken to break up such eddies, they appear to remain permanently—a mute protest of the river against the infringement of its natural laws. The writer is aware of one case where a training dike was prolonged so that it impinged on the natural flow at about the same angle as did the west jetty of the South Pass, and a survey made 22 years after its construction showed the usual basin scoured out and still existing at just that point where the flow had been forced from its natural direction.

A still more instructive example of the laws of flow is to be seen in Galveston Harbor, Texas. The improvement of this bay was dependent entirely on the tidal currents, which have a mean range of only 1.1 ft. As will be seen from Plate LIV, the main channel, when the final improvement was commenced, curved around the Bolivar Peninsula, reversed its course, and passed over the bar in a southeasterly direction. Before any improvement was begun, the channel to the bar, in accordance with the conditions found at nearly all large outlets, varied within a fixed quadrant from nearly east to nearly south, but never passing beyond those limits.

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* "The Mississippi Jetties," p. 151.

The first work was done in 1874, when a gabionnade, replaced later by a structure of brush and stone, was commenced on the location of the present south jetty. When completed, however, no betterment of channel resulted, except that the bar-crossing, being somewhat protected from storms, became much less shifting, and it was therefore decided to build a north jetty.

It will be seen from Plate LIV that during and after the completion of the jetties, approximately the same elements of flow were preserved and the same radii. As the works advanced, the outlet of the channel followed, curving in its course and opening to the southeast, and when they had been completed, it ran in a curve of long radius from the tangent between the points of reversion, impinged upon the north jetty, and swung to the southeast again, passing as close as possible to the end of the south jetty. The survey of 1902 indicates a radius for the gorge of about 13 000 ft., and an average radius, for the channel from the gorge to the bar, of about 13 500 ft. The latter, during its extension, appears to have reached a maximum of between 17 000 and 18 000 ft., which lessened as the water settled to a permanent course. The eastward extension of the bank on the north flank of the south jetty broke to some extent the regularity of curvature at the bar as the bank worked seaward, but, from present indications, it seems possible that the growth of this point has reached a stage where the currents will be able to hold it in check. This bank is supposed to be due to the scoured material being deposited in the eddy of the curve. Attempts to straighten the entrance by dredging parallel to and about midway between the ends of the jetties have proved fruitless, as the water always replaces the material removed and retains its curved channel.

The success of this work, which increased the depth on the bar from 12 to 27 ft. in about 12 years, and made Galveston one of the leading ports of the United States, was due to the wide basin left between the jetties near their shore ends. This space allowed the

PLATE LIV.
PAPERS, AM. SOC. C. E.
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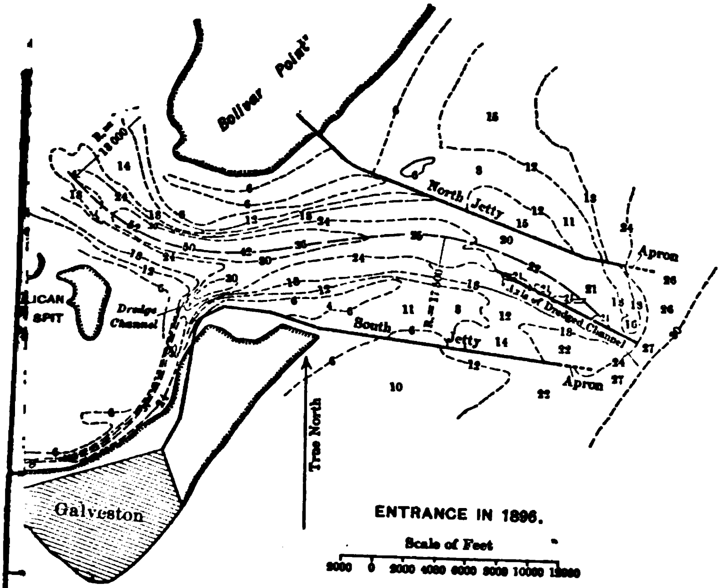
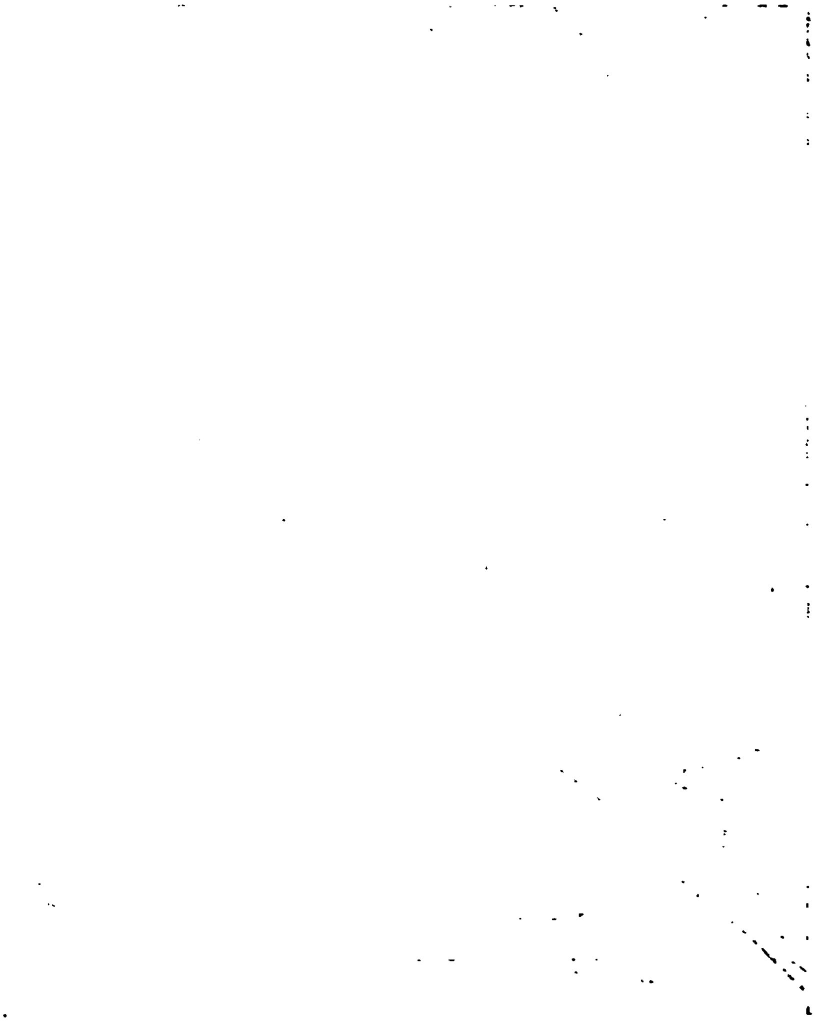
RIVER AND HARBOR OUTLETS.



ENTRANCE IN 1896.

COMPARATIVE SURVEYS
OF ENTRANCE TO
GALVESTON, TEXAS



current to continue its natural course, and gave it room enough to create its new channel without disturbing the balance of its forces. Had the jetties been built close together, so as to force the water in a straight line, there can be little doubt that the natural tendencies would have been gradually dissipated, and a shallow and unsatisfactory channel would have been the result. As before noted, in creating the new channel the current adhered approximately to the dimensions and curvature it before held in its natural state when approaching the bar, and, although the water was given unusual room in which to create new channels, it has slowly and surely continued to fill in all the spaces lying outside of its required course. The conditions here, as at the mouth of the Mississippi, are modified but little by sand-drift and littoral currents.

From the resulting conditions it would appear that in this case a geometrical solution of the problem, as to the course the new channel would take, would have been obtained by drawing in a southeasterly direction a line through the 30-ft. contour nearest to the original outlet, and joining this by a curve of radius equal to that of the channel to the bar before improvement, to an extension of the curve of the Bolivar Gorge, the two curves meeting on a common tangent, thus preserving the elements established by Nature.

6.—Experience seems to show that the question of the advance of the bar, which was formerly a much-discussed point, is not a serious factor where the works have been well designed and rapidly carried out. The pockets formed by the jetties on their outsides offer receptacles in which the sediment or sand-drift gathers, sometimes behind one jetty only, the other one showing erosion, sometimes behind both. With a good depth of water, also, the sediment has a wide field for deposit, and, as a consequence, the bottom builds up slowly.

This question gave rise to apprehension of serious trouble at the mouth of the South Pass of the Mississippi, where it was claimed that the jetties would have to be advanced into the Gulf every few years. In point of fact, however, no extension has ever been made, nor is any contemplated. The vast amount of sediment brought down has been deposited behind them to the east and west, as the charts show, and the river has never failed to maintain a channel to the open sea.

Mr. Vernon-Harcourt states that at the Harbors of Sunderland; Ymuiden, Dublin, and Port Said, the advance of the foreshore proved to be much less than was anticipated; and, at the Sulina Mouth of the Danube, which discharges a great quantity of sediment, Sir Charles Hartley stated that the rate of advance of the bar, according to observations taken for 10 years after the completion of the works, had been reduced by the improvement more than one-half.

With the St. Johns River, and at other localities, the improvement of which was continually delayed by lack of funds, the eroded material and the sand-drift appear to have followed closely the gradual extension of the jetties. This feature is very noticeable on the maps of the St. Johns, and constant dredging is anticipated if a good depth of channel is to be maintained at that entrance.

Where waves break in a considerable depth of water, or where the outside currents flow in a similar depth, the bottom appears to be slightly, if at all, disturbed, but where the depths are shallow, the waves and currents may bring into an entrance or a dredge-cut a constant supply of fresh material. Tests recently made at Cumberland Sound showed that coarse sand and shell, when stirred up by breakers, were carried to a considerable distance by light currents, and were not deposited until smooth water was reached. The same materials in quiet water lay undisturbed by currents flowing as rapidly as 4 ft. per second, although fine sand was moved by comparatively light currents.* Major W. M. Black, Corps of Engineers, in his paper before the International Engineering Congress of 1893,† quotes a case of a bank of fine sand which withstood a current of 3 ft. per second, but which was quickly eroded when the current was accompanied by a slight wave action.

With the Galveston Jetties, it was found that the bar was pushed seaward with the advance of the works, keeping pace with them as long as the depth of water remained shallow, the material eroded by the current being replaced by the local forces of the waves, etc., which had caused the original formation. It was only when the jetties reached deep water that the scour began, and then the effect was rapid, and has remained permanent and self-sustaining.

7.—The advisability of advancing both jetties at once results

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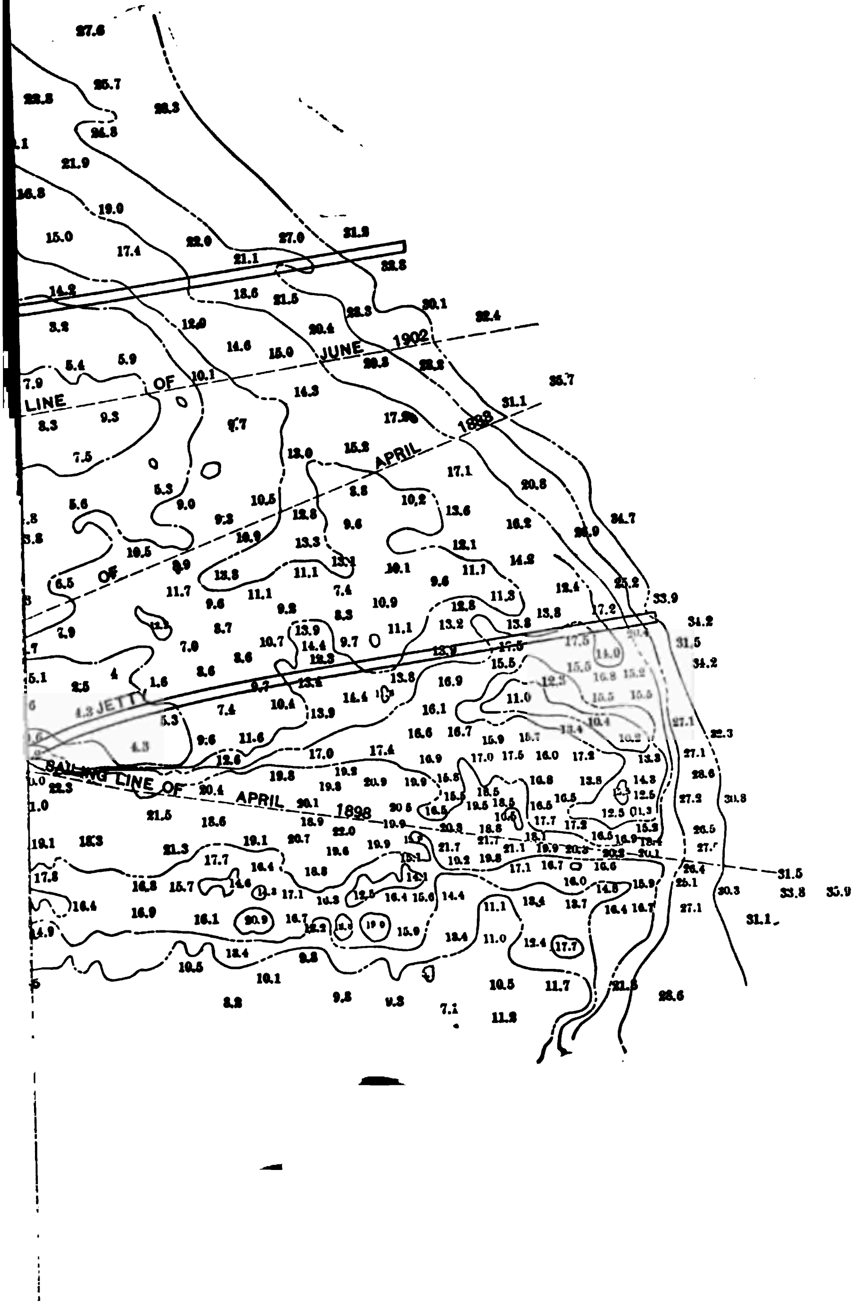
* Annual Report, Chief of Engineers, U. S. Army, 1902, p. 2308.

† *Transactions*, Am. Soc. C. E., Vol. XXIX, p. 293.

PLATE LV.
PAPERS, AM. SOC. C. E.
MAY, 1905.
WATT ON
RIVER AND HARBOR OUTLETS.



from the universal tendency of outlets exposed to sea influences to undergo a periodic alteration of channel, and, unless this can be forestalled, serious trouble may ensue, as instanced further on.

Regarding low jetties, Charleston Harbor, Cumberland Sound, the St. Johns River, and the Columbia River (a single jetty), may be cited as examples in the United States where such jetties have proved unsatisfactory, or have indicated that better results would have been obtained by higher ones, and the changes have been, or are to be, carried out, accordingly, by raising all or part of the works. As these outlets are typical ones, and experience with them has covered a period of many years, it appears to be safe to assume that the principle of low jetties is not usually an advantageous one.

8.—No engineer who has had experience with jetty work protracted for a long period of years, or who has studied the effects upon the channel during year after year of construction thus carried on, can fail to have been impressed with the seriousness of the results which may ensue from such delay. With channels of constant location the problem would be reduced principally to repairing damage from storms and to taking care of sand-drift or erosion, but with the shifting channels, the presence of which is almost universal, the original location of the jetties, in the end, is likely to be found to be of no value to commerce. An instance of such a risk is to be seen in the oft-quoted improvement of Cumberland Sound, on the southern coast of Georgia. (Plate LV.) This work was first projected in 1879, and has been carried on since then to successful completion in the face of unusual obstacles. Always hampered by lack of funds, the construction was continued year by year as finances would permit, the channel during the interval changing until the entrance was at one time blockaded by sand, and the ship-channel passed outside the jetties, and the improvement, which was estimated to cost more than $2 000 000, was looked upon by many as an example of hopeless failure.

Work was begun in 1880, at which time the main or northerly channel ran to the bar about east-northeast or northeast, between the projected location of the jetties. The bar had from 11 to 13 ft. on it, with a mean tide range of about 6 ft., and the improved depth was to be 19 ft. This channel, shortly after work was begun, commenced a period of change and began to move southward, the map of 1886 showing two channels, one running about east and the other about southeast, and the report drew attention to the need of prompt extensions of the jetties in order to stop the shifting of the flow. By 1892, however, the sailing channel had swung to the south, crossing the end of the south jetty about 7 000 ft. from its commencement (work there having to be suspended in consequence), and thence running on the outside of it almost due east to the bar.

This condition of affairs continued for some years, the space between the seaward portions of the jetties, which were then considerably below low tide, gradually shoaling up, and the outlet of the sailing channel swinging further to the south, until about 1896 it reached its limit and began to shoal, a northerly channel having shown signs of opening along the north jetty during the previous year.* Apparently, however, this was inadequate for ships, which had to continue to use the southerly channel. The map of 1898 shows the latter as having returned to an easterly course, almost parallel to, and still outside of, the jetties, while the channel inside them was a shallow outlet passing to the north of a sandbank which stretched across two-thirds of the enclosed space.

So serious was the condition of affairs that the port was almost blockaded, and a portion of the south jetty at the channel crossing had to be removed, and dredging resorted to to relieve the urgency of the case. In 1900, however, a new channel between the jetties began to open, the ship channel still lying across the south jetty, but slowly shoaling. Dredging was commenced to assist this, and proved of material benefit, and by 1902 it had deepened sufficiently to permit of the south channel being abandoned and the gap in the jetty being closed. The new channel is reported to be of good depth and width, although, owing to the comparatively shallow depths between the ends of the jetties (19 or 20 ft.), the bar crossing is shifting. As the work is now practically completed, the jetties will guard the outlet from further serious change, but it is doubtful if the channel will ever reach the condition it might have attained had financial reasons permitted rapid construction.

Where funds do not permit sufficient work to control an outlet satisfactorily, experience seems to indicate the advisability of concentrating expenditures on one jetty only, which, it is believed, should be located on that side of the channel toward which the movement is tending, with the object of arresting any change. While the entrance will probably still continue to shift, it will be within narrower limits, and with less danger of escaping entirely from control, as did the channel at Cumberland Sound. The extreme positions of the field of change would, of course, prove inadvisable for the location of such a jetty, and the writer is inclined to believe that under usual conditions the best time for its construction would be when the channel has swung to about midway between its furthest limits.

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* Annual Report, Chief of Engineers, U. S. Army, 1897, p. 1534.

9.—The method of assisting the scour of jetties by dredging is to be used on the new work at the mouths of the Southwest Pass of the Mississippi, of the Columbia River in Oregon, and elsewhere. It is already in use in many localities, and in all countries, and has generally proved satisfactory, since results can be obtained more rapidly and certainly. In some cases dredging has been relied on entirely, where the construction of jetties would have been too expensive; and, where the cuts have been located along the natural axis of the flow, under the same rules as should be followed in locating the jetties, the results have been very satisfactory. Where the cuts have not been thus located, they have filled up more or less, in the same way as has been found to be the case in dredging bars in rivers.

Vol. XXXI. MAY, 1905. No. 5.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PAPERS AND DISCUSSIONS.

This Society is not responsible, as a body, for the facts and opinions advanced in any of its publications.

A NEW SWING BRIDGE AT COPENHAGEN, DENMARK.

Discussion.*

BY MESSRS. JOHN C. MOSES, H. T. FORCHHAMMER AND L. J. LE CONTE.

Mr. Moses. JOHN C. MOSES, M. AM. SOC. C. E. (by letter).—Swing bridges of two well-known types have been in use for many years. In one type the loads are carried by a circular drum resting on a ring of conical wheels which rests in turn on a track on the pier. A central pedestal holds everything in position laterally and carries a portion of the load, to insure its staying in place. In the other type the entire load is carried by the central pedestal, and balance wheels and track are provided to prevent the span from tipping when turning. In a large bridge of this type it is necessary to provide wedges or jacks at each end of the center cross-girders which will carry any transversely unbalanced live load, such as a train on one of two tracks. In both types the ends are lifted after closing the bridge.

Both types require a good deal of machinery when the bridge is a large one operated by power from a central house. The first cost is large, the work is expensive to erect in satisfactory adjustment,

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* This discussion (of the paper by H. C. V. Moeller, Esq., printed in *Proceedings* for March, 1905), is printed in *Proceedings* in order that the views expressed may be brought before all members for further discussion

Communications on this subject received prior to June 23d, 1905, will be published subsequently.

Mr. Moses.

it is likely to be deranged subsequently, and it is difficult to protect the machinery from bad weather. Proper provisions for temperature changes and live-load deflections add much complication on a long span. Indicators, brakes, buffers and other safety devices are used to protect these exceedingly heavy pieces of moving machinery from self-destruction. Running expenses are high, repairs frequent, and complete break-downs not unknown. Nearly every new bridge designed is an attempted improvement on previous ones which have developed this or that defect. Therefore, it is of great interest to examine the design outlined by the author, as it presents such novel features, and is in successful operation.

Many of the old difficulties at once disappear. End-lifts and side-wedges, with their gearing, shafts, boxes, indicators, automatic brakes and safety devices, are entirely eliminated. Hinged pedestals with roller bearings can be provided at the ends to take care of the temperature and deflection changes, as in fixed spans. The ends can be raised the exact amount required by theory, and any necessary adjustment can be easily made by the use of shims. While end-locks and buffers may be advisable for a heavy bridge, they could be dispensed with on ordinary spans. V-shaped grooves in the end bearings would center and lock in place the trusses. A good hand-brake on the turning gearing and a controller such as used for crane work will quickly place, and hold in position while being lowered, a span weighing 500 tons. A possible objection to thus holding the bridge in place with the turning machinery might arise in this new type from the vertical motion of the pinion on the rack, or on its shaft, when the bridge is lowered, but, with the ordinary types, it is entirely feasible.

The author has provided his turning machinery in duplicate. The usual practice is to rely on hand-gearing in case of accident. This means very slow work with a large bridge. While he, no doubt, has hand-gearing also, he is not likely to have to use it, and the extra cost of the duplicate equipment seems to be a wise investment.

The feature of chief interest in the design is the hydraulic pivot. The general scheme with the heavy and light accumulators is simple, and the return-water tank is an ingenious method of overcoming a difficulty. A full detail of the pivot would be of great interest, and the writer hopes it will be added. The success or failure of the entire scheme will depend on the efficiency of the detail used for packing the 5-ft. revolving plunger, with its load of 875 tons. No hand-gearing or duplicate machinery will remedy a leak here. Loss of pressure in the pivot, due to breakage in pipes or accident to accumulators, might be prevented by an automatic check-valve; but it is difficult to see how an accident to the pivot

Mr. Moses. ram can be prevented from being very serious. The provision for holding the pivot vertical also seems to be elaborate, and probably cost as much as the usual track and wheel ring. The accumulators with their pumps, and the enlarged pier needed to hold them, will cost more than the ordinary end-lifts and side-wedges. If an assistant is required in the pier, the cost of wages for operation will exceed that of the ordinary types. Does the bridge then show a freedom from wear and break-downs that would justify the future use of the same plan? A fuller presentation of the details for study would help to anticipate the verdict of time. Further information and a report of any actual difficulties thus far met will add much to the author's interesting paper.

Mr. Forchhammer. H. T. FORCHHAMMER, ASSOC. M. AM. SOC. C. E.—The speaker was Assistant Engineer to Mr. Moeller, at the time this bridge was built, and desires to add some further explanation of some of the details of this very interesting paper.

A glance at the "section on *h—i*" of the main span, on Plate XXIII, will show how important it was to get the space between the steel bottom and the rock entirely filled with cement. The plan beneath the "section on *d—e*" (Plate XXIII) indicates the pipes, *T, T*, through which the cement was led down, and *S, S*, the pipes through which the water was led away. In passing through the water large quantities of cement were transformed into "laitance," but, when all the water was led away, it would have been impossible to raise the laitance through the pipes because its specific gravity, or the specific gravity of the mixture of water and laitance, was greater than that of water. Therefore, in order to get rid of the laitance, three of the pipes marked "*S*" were provided with valves at half their height, and, when all the water had escaped these valves were opened and the filling with cement was continued until all the laitance was out.

Attention might be called to the hydraulic buffers on this bridge, as they operate successfully and save much time. The speaker does not know whether such buffers are in use in the United States. Their advantage is that they check the movement of the bridge at the same spot, whatever the velocity at which the bridge is revolving when it strikes them, and the impact is reduced to a resistant force of the same amount under the entire blow. At Calais, France, the speaker has seen two draw-bridges, with such buffers. One of these bridges was moved with full speed against the buffers, and they, with a movement of about 24 in., stopped the bridge in about 3 seconds, exactly in its central position, so that it could be locked without any waste of time.

The mechanism of the Copenhagen bridge is more complicated because the bridge is arranged to be swung in either direction. The

Mr. Forchhammer. principle, which was original with the Smith, Mygind and Hüttemeier Steel Company, of Copenhagen, is shown clearly in Fig. 3. When a bar attached to the bridge strikes one of the rollers marked *a*, the fluid in the cylinder is compressed and creates a resistance as it passes from the front to the rear of the valve through some small openings in the latter.

Bridges of this general type seem to have attracted some attention. As far as the speaker knows, this type has only been used for a few smaller bridges in Germany. In England, hydraulic accumulators have been used for many swing bridges, to diminish the friction on the rollers, but hydraulic pressure has never been used to lift the bridge.

HYDRAULIC BUFFER

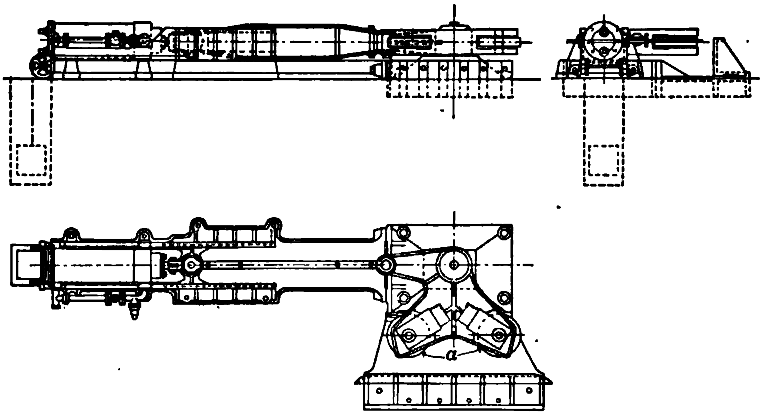

Fig. 8.

The collar bearing is shown on Fig. 1, but on a small scale. It is built as a sliding bearing and can be adjusted by the tap-bolts and wedges, as shown. This bearing, as well as the pivot, is built up of heavy steel castings, and is strong enough to resist the pressure of a heavy wind on the superstructure.

A diagram of the hydraulic machinery is shown on Fig. 2, with the accumulators, pumps, valves, pipes, etc. In addition, it should be mentioned that just outside the pivot and each accumulator is a safety valve which will prevent the heavy weights from falling suddenly in case any of the pipes should break.

This bridge has been criticised* as having too little depth, too

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* *The Engineering Record*, April 8th, 1905.

Mr. Forchhammer. great a number of members, excessive deflection, as lacking grace, etc. Considering the very shallow depth of the floor, which had to be maintained, the speaker believes that it would have been very difficult to build a more economic structure, and is sure that greater depth of truss and longer panels would not have added to its beauty.

Mr. Le Conte. L. J. LE CONTE, M. AM. SOC. C. E. (by letter).—It is really very difficult for an American engineer to understand and discuss fairly the heavy types of riveted bridges, such as are built so commonly in Europe.

The details of the plate-girder approaches will compare fairly well with those usually adopted by American bridge engineers; but, in the swing span, a very wide divergence is found, in the short panel lengths, only 9.5 ft.; the height of the center tower, only 28 ft.; the height of end posts, only 9.2 ft.; and, finally, a dead load of something like 8 100 lb. per running foot. These apparently abnormal conditions are all very hard to understand, yet, nevertheless, one is compelled to respect and admire such good construction. There is one feature about the swing span which is certainly praiseworthy, namely, the two solid bearings, 8 by 2 ft., one on each side of the center pier directly under the main trusses. This detail, in some respects, is to be preferred to the ordinary turn-table with roller bearings. On the other hand, when it comes to operating the draw-span device with a hydraulic lift for raising the swing span clear of its supports, it is not to be commended. This device brings a terrible local strain on the bridge just over the center pier; in point of fact, it is nothing more than an extreme case of center-pintle bearing, with all its well-known serious disadvantages. American bridge engineers have practically abandoned the center-pintle bearing as being obsolete and condemned by experience, although, theoretically, it makes the easiest turning swing span.

If an American engineer were called upon to design such a draw span, he would, in all probability, select the pin-connected type as being best adapted to the case in hand.

The double tracks and floor system would be identically the same, in every particular, the main difference being the trusses and turn-table device. Such a span could be built, first-class in all respects, with a dead load not exceeding 5 000 lb. per running foot. This design, moreover, would be capable of withstanding a concentrated load and a railway live load far in excess of the loads mentioned by the author. The writer would not have it understood from this, however, that he is constitutionally opposed to riveted bridges; on the contrary, he is a firm believer in the wisdom of using heavy riveted work for all single-track bridges, up to spans of 200 ft. or thereabout. For double-track bridges heavy riveted work is best, up to spans of about 100 ft., as it furnishes more dead load and greater rigidity (two highly important features for smaller spans) and, at the same time, gives far better general satisfaction. For all spans of more than 100 ft. for double-track, and of more than 200 ft. for single-track bridges, the pin-connected bridge is by far the better and cheaper construction. **Mr. Le Conte.**

Vol. XXXI. MAY, 1905. No. 5.

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THE COMPENSATING WORKS OF THE LAKE SUPERIOR POWER COMPANY.

Discussion.*

By L. J. Le Conte, M. Am. Soc. C. E.

Mr. Le Conte. L. J. Le Conte, M. Am. Soc. C. E. (by letter).—The author of this most interesting paper apparently invites discussion on the compensation devices adopted, but, nevertheless, does not furnish the data necessary for a complete discussion, thus leaving much to mere assumption.

There are eight bridge spans furnishing areas for discharge, hence the average discharge at low stages must approximate 7 000 cu. ft. per second for each span; but, from other sources of information it is found that the separate discharges at each span at low stage would be more approximately as follows:

Canadian Side—Span	1....	2 550	cu.	ft.	per second.
"	2....	10 070	"	"	"
"	3....	11 670	"	"	"
"	4....	10 950	"	"	"
"	5....	10 940	"	"	"
"	6....	6 820	"	"	"
"	7....	1 790	"	"	"
American Side— "	8....	1 367	"	"	"
Total discharge..........		56 157	"	"	"

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* This discussion (of the paper by G. F. Stickney, Assoc. M. Am. Soc. C. E., printed in *Proceedings* for February, 1905), is printed in *Proceedings* in order that the views expressed may be brought before all members for further discussion.

Communications on this subject received prior to June 23d, 1905, will be published subsequently.

Mr. Le Conte.

It is clear, of course, that the greatest public danger to be apprehended is the bare possibility of lowering the lake level below the minimum record. In considering such problems, it is always safer to consider the very worst features that could possibly arise; because the worst conditions have a faculty of always happening at the very time when one is least prepared to meet them.

If it be assumed that the four sections are actually built, as suggested by the author, then there will probably be the following volumes for discharge purposes at low stages of the lake:

		Cubic feet per second.
Span	1. Embankment.....	0
"	2. Closed sluices....	0
"	3. High dam.......	0
"	4. Submerged weir..	2 170
"	5. Unobstructed flow	10 940
"	6. " "	6 820
"	7. " "	1 790
"	8. " "	1 367

Total flow........23 097 cu. ft. per second, to be deducted
from 56 157 " " " minimum flow

leaving 33 070 " " " to pass down
through the canal to the power-house.

This quantity seems to be uncomfortably close to the actual requirements, 32 000 cu. ft. per second, for power purposes.

In view of the many uncertainties connected with these calculations, such as high wind in combination with "big high" barometer at the east end of the lake, or a "big low" barometer at the west end of the lake, all of which are powerful, yet largely unknown, quantities tending to lower the low-water plane below the present record; it would seem, under the circumstances, far more advisable to put in another span of sluices. This would certainly give more complete command of the outflow at the head of the rapids at times when it is most needed.

The writer would be pleased to know the reasons for selecting the site of the regulation works above instead of below the bridge.

The difficulties met in contending with the swift current, and the manner in which they were finally overcome, are very instructive and highly interesting. The writer has had similar experience, and in many cases has found it more advisable, in many respects, to build the cribs in the form of an equilateral triangle in plan with the point up stream, as it was found that they could be

Mr. Le Conte. handled much more easily in a swift current. The plan usually adopted in freezing weather is to shut down and quit work for the season, hence the author's description, of how they housed in the work on the sluices and heated the enclosure and the materials artificially, so that the men were able to live comfortably under cover and do good work, is certainly very instructive.

The writer was somewhat surprised to note the proportions adopted for concrete in the foundation work. It seemed to him that, for a foundation course, approximately 240 by 40 by 7 ft. thick, it would have been more advisable to use rubble masonry laid with 4 to 1 mortar, the top course of paving stones, of course, being laid and pointed with 2 to 1 mortar. In the same way, the backing for the masonry in the piers could just as well have been made of rubble masonry with 3 to 1 mortar, the facing stones being laid and pointed with 2 to 1 mortar. However, these are all small matters, which do not detract in the least from the value of this highly commendable paper.

MEMOIRS OF DECEASED MEMBERS.

NOTE.—Memoirs will be reproduced in the Volumes of *Transactions*. Any information which will amplify the records as here printed, or correct any errors, should be forwarded to the Secretary prior to the final publication.

FREDERICK de FUNIAK, M. Am. Soc. C. E.*

DIED MARCH 29TH, 1905.

Frederick de Funiak, Civil and Mechanical Engineer, was born on August 15th, 1839, in Rome, Italy. His father, Count de Funiak, was a Colonel in the French service.

Frederick de Funiak received his early education in Rome. Later, he went to Vienna, Austria, to the Military Academy, and was graduated in 1857 as Lieutenant of Engineers.

He was sent to Egypt as Assistant Engineer of the first railway built in Egypt, from Alexandria to Cairo. He remained in Egypt until 1859, when he was recalled, and served during the Franco-Italian and Austrian campaigns on the staff of General Sonaz. At the Battle of Solferino he was made Captain. After the Peace of Villa-Franco, he served with Garibaldi. In 1862 Mr. de Funiak came to the United States, which were at that time disunited. Having letters of introduction to General Dick Taylor, of the Confederate Army, he made his way to Memphis, Tennessee, and joined General Taylor's brigade as Captain of Engineers, with headquarters at Meridian, Mississippi. He was with this command throughout the remainder of the war.

After the surrender he went to Memphis and taught mathematics and the languages in several schools and colleges, and also did some engineering work for the city in compiling new maps of Memphis.

In 1866 he was appointed Resident Engineer of the Mississippi River Bridge Levees, and was stationed in Washington County, Mississippi. In 1867 he became Assistant Engineer of the Memphis and Charleston Railroad, and built the Tennessee River Bridge, at Athens. In 1869 he was engaged on the water-works commission, determining a water supply for Memphis. In 1870 he became Chief Engineer of the Mississippi Central Railroad.

In 1871 he was sent to Europe as the joint agent of the Mississippi Central, the Memphis and Charleston and the Virginia-Tennessee Air Line, Railroads. In 1872 he built the Ripley Narrow-Gauge Railroad, the first road of this kind built in America. In 1873 he became Chief Engineer of the main line of the Louisville and Nashville Railroad, and in 1874 he was made Chief Engineer of all roads owned and leased by that system. In 1876 he was

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*** Memoir prepared by James Geddes, Esq., and E. C. Lewis, M. Am. Soc. C. E.**

appointed Chief Engineer and Superintendent of Machinery, and in 1879 he became General Manager of the entire system, which position he held until 1883. During this time he was Chief Engineer of the Henderson Bridge Company, General Manager of the Nashville and Chattanooga Railroad, and President of the Pensacola and Atlantic Railroad. He resigned all these positions, on account of his health, and went to Carlsbad. On his return to America he never resumed active work.

In 1865 Colonel de Funiak married Miss Olivia Browning, of Memphis, who, with their four sons, survives him at Louisville, Kentucky, where he died on March 29th, 1905, at the age of 65. He was a genial, attractive man; in his youth a daring, dashing fellow, on the lookout for any adventure; a soldier of fortune, withal a man of letters and learning.

He was elected a Member of the American Society of Civil Engineers on May 7th, 1873.

EDWARD SHERMAN GOULD, M. Am. Soc. C. E.

DIED JANUARY 24TH, 1905.

Edward Sherman Gould was born in the City of New York on August 13th, 1837, and died of pneumonia, while stopping for the winter in the same city, on January 24th, 1905.

He came of a long line of distinguished native American ancestry on both sides. His father, of the same name, was the son of Judge James Gould, third or fourth of the name in America, of Litchfield, Connecticut, and Sally McCurdy, daughter of General Uriah Tracy, fifth of the name in America. His mother was the daughter of Cornelius Du Bois, fifth of the name in America, and Sarah Platt, daughter of Robert Ogden, fifth of the name in America.

His early education was under the direction of private tutors. In 1855 he went to Europe with his family, and spent several years in travel and study. In 1856 he made a voyage, "before the mast," from Bordeaux, France, to New York. This sea experience was always greatly prized.

In 1858 he commenced his more serious scientific education, entering the Ecole des Mines de St. Etienne, France, as "élève étranger," on application of the Honorable J. G. Mason, then United States Minister to France. On leaving this school he made journeys through the principal coal and iron districts of Great Britain, Germany and Belgium. From 1862 to 1865 he was Secretary to the

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* Memoir prepared by S. L. Cooper, M. Am. Soc. C. E.

Honorable John Bigelow, then Consul-General of the United States at Paris.

In 1865 he returned to the United States, and accepted the position of Engineer to the New York and Schuylkill Coal Company, succeeding Charles Macdonald, M. Am. Soc. C. E. His next position was as Division Engineer on the Buffalo Extension of the Atlantic and Great Western Railway, which he resigned in 1866 to become Engineer and Surveyor of the Bricksburg Land and Improvement Company, owning the tract now known as Lakewood, New Jersey. In this position he succeeded the late Samuel H. Shreve, M. Am. Soc. C. E.

In 1868, while in this employment, he married Arabella Duncan, youngest daughter of the late Dr. Edward Greenleaf Ludlow, an eminent New York physician, and the late Mary Kennedy Lewis, great-granddaughter of Francis Lewis, one of the signers of the Declaration of Independence.

In 1871 he was Locating Engineer for the projected Augusta and Hartwell Railway, Georgia, of which Mr. Charles Seymour was Chief Engineer. From 1873 to 1876 he was Civil Assistant Engineer to the late General Q. A. Gillmore, United States Corps of Engineers, on river and harbor improvements in the South, and in the reconstruction of Forts Sumter and Moultrie, Charleston, South Carolina.

In 1877 he became Assistant Engineer in the Bureau of the Croton Aqueduct, Department of Public Works, City of New York, under the late John C. Campbell, Chief Engineer. While in this position he made investigations for an increased water supply from the Housatonic River, and also from the Bronx and Byram Rivers, and was afterward in charge of the construction of the Kensico Reservoir and the upper section of the 48-in. pipe line in connection with the same. Upon the completion of this work he commenced the preliminary surveys for the new Croton Aqueduct.

From 1884 to 1886 he was Division Engineer of the new Croton Aqueduct, but left this position for the reason that his strict sense of duty and high professional honor rendered him *persona non-grata* to the contractors. Those who recall the conditions surrounding this work at this period will understand the reason, most creditable to Mr. Gould, that led to the severance of his connection with this work.

From 1886 to 1890 Mr. Gould was Consulting and Executive Engineer to the Scranton Gas and Water Company. During this connection he built the Oak Run, the Dunnings, and the Meadow Brook Dams and Reservoirs. From 1890 to 1894 he was Consulting and Constructing Engineer for Runkle, Smith and Company, American contractors for the new Havana Water-Works, known as "El Canal de Albear." At the same time he was also Engineer in Charge of the Palatino Reservoir.